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FIFTY YEARS OF FLYING PROGRESS

BY

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Fifty years is, actually, not a very long time in the development of one of humanity's greatest means of transportation, but when we stop to appraise aircraft development in this period, and compare the original first machine to fly successfully, the Wright "Kitty Hawk," with our latest supersonic airplanes, we see the most striking and convincing progress in speed. A gain of well over 1200 miles an hour in 50 years would average out at 24 miles an hour faster each year.

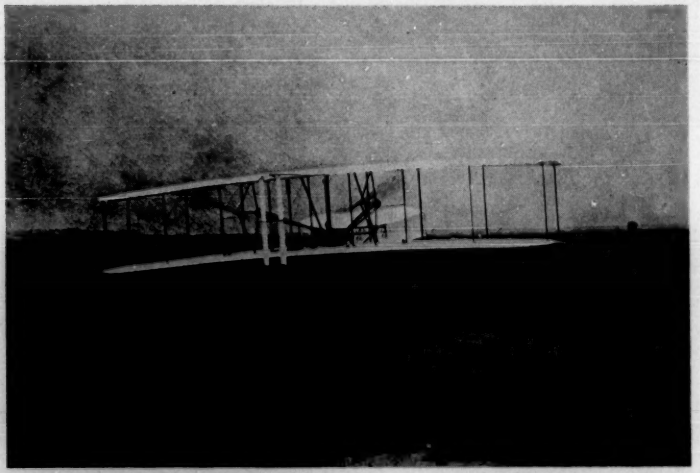

FIG. 1. Thirty miles an hour in 1903. (The Wright "Kitty Hawk.")

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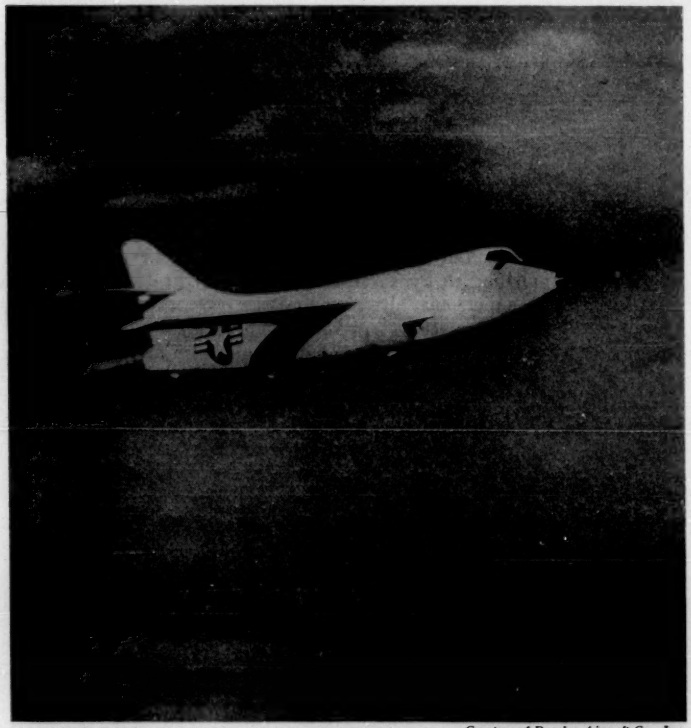
Curiously enough, this is approximately the rate of progress that actually did take place for several years after 1909. The Wright Model B at 40 miles an hour and the original Curtiss at about the same speed in 1909 were outclassed in 1910 when Leblanc on a Bleriot raised the record to 68 miles an hour. In 1911 the Nieuport did 82 miles an hour. In 1912 the Deperdussin raised this to 108. And so on through



Courtesy of Douglas Aircraft Co., Inc.

FIG. 2. 1230 miles an hour, less than 50 years later. (The Douglas "Skyrocket.")

the years. The official records today are of course not yet inclusive of the actual speeds made by supersonic aircraft due to the secrecy that is maintained. But this much we can say—that if the unfailing record of the years continues, by the year 2003 aircraft will be flying at 2400 miles an hour! While it is true that the present supersonic aircraft are merely research airplanes of very small load capacity,

more practical load-carrying airplanes quickly catch up with the initial record-breaker. For example, when subsonic jet aircraft single-seater fighters of recent British and American development, like the Meteors and the Lockheed Shooting Stars, arrived at the 500 mile-an-hour class, it was not very long before the Comet airliner carrying over 36 passengers was doing the same thing. So it will only be a short few years before load-carrying aircraft will be equalling and exceeding the speed of the present supersonic airplanes.

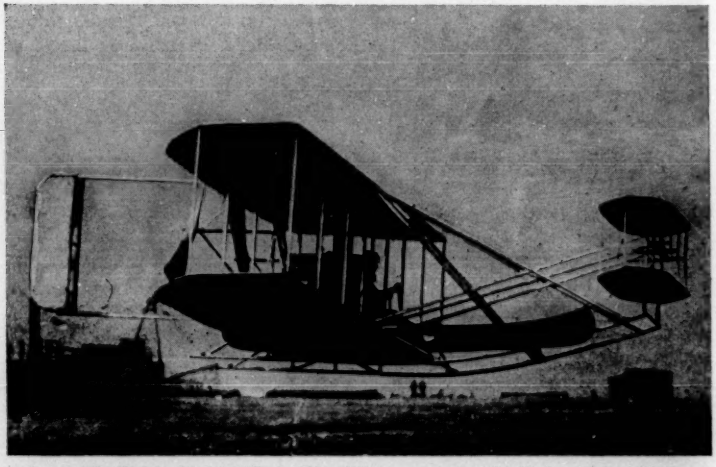


FIG. 3. The Wright Model "A" of 1909, with canoe attached for Hudson-Fulton flights over New York Harbor. Skid landing gear, no wheels, no rear horizontal tail.

SLOWER LANDING SPEED

While speed gain is the outstanding successful evidence of our great progress these 50 years, the lack of attainment of low speed for landing is our outstanding failure. The very early Wright airplanes had so much parasite drag resistance, so much area with accompanying skin friction, and yet so light a total weight that they could literally be almost dived at a landing spot and then flared out. So, it was possible for landings to be made in very restricted areas with high obstacles. One of the outstanding feats in this category was when Harry Atwood landed his Wright Model B on the south lawn of the White House in 1912.

Early Wright, Curtiss, and Bleriot exhibition teams flew constantly and with great ease off race tracks and even ball parks throughout those exciting exhibition years (1909 to the beginning of the First World

FIG. 4. The 1909 Curtiss biplane. Engine back of pilot, interplane ailerons, shoulder yoke controls, three wheel and skid landing gear, front and rear elevators.

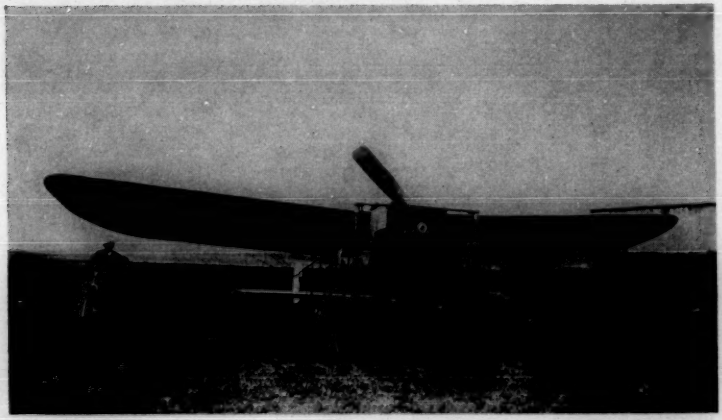


FIG. 5. The 1909 Bleriot monoplane. Tractor engine location, warping wings for lateral control, rear elevators and tail.

War)—when the public was being entertained by aircraft to so great a degree, and when the real business of the industry was chiefly building for exhibition work and racing and only in a minor way for military usage. Of course the wing loadings of aircraft in those days was around two to four pounds a square foot for biplanes and three to six pounds a square foot for monoplanes, and the light loading had much to do with this early small-field-ability. But we have a great loss in aircraft value as of today in having failed to maintain this ability, and failing to such an alarming extent that 10,000-foot runways are now considered too short. Landing speeds of 200 miles an hour are seriously talked of, and the aircraft engineering fraternity, in too large

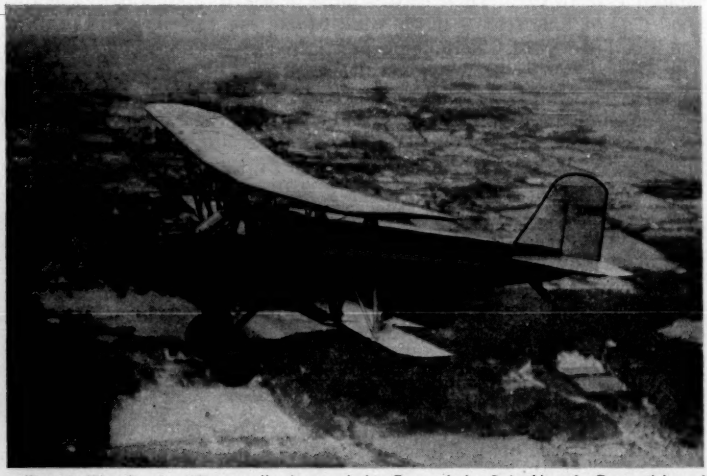


FIG. 6. The Curtiss "Tanager," winner of the Guggenheim Safe-Aircraft Competition of 1929. Outboard ailerons on lower wing, complete slots and flaps. This plane had by far the best speed range up to that time.

measure, goes blithely on its way ignoring the heavy burden on practical progress and usage that aircraft development is placing on itself by not realizing that we have failed miserably in advancing the technique of slower landing speeds and shorter field usage. The Wrights showed a way we seem loth to follow.

To be sure, there has been some development of high lift devices, a very useful development of wing flaps and air brakes without which even the present fast airplanes would be so hopelessly handicapped that there wouldn't be enough real estate around to take care of them at all. Also, of course, we have the development of the helicopter of recent years to somewhat offset our failing in extending downward the speed

range of fixed-wing aircraft. But the helicopter has the very serious deficiency of being a slow aircraft—very useful to be sure, but by no means the final answer until it can carry loads very much faster.

The economics of air transport, particularly in the requirements for such large landing areas (which, while many are built with government funds, are nevertheless a burden either to the taxpayer or the operator who pays a landing fee), shows that these cannot possibly grow with the growth that aircraft usage should have in the coming years unless we reverse the trend and get busy now to reduce landing speeds every time that we also make an increase in the high speed.

Interestingly enough, one of the later activities of Orville Wright around 1923 to 1925, when he was more or less retired, was to spend a good deal of time testing in his wind tunnel the various series of flaps and high lift devices which are now exhibited at The Franklin Institute. The ordinary split flap was patented by Orville Wright in 1924, and very few people realize that he was the inventor of this device. The Guggenheim Aircraft Competition came along in 1929 and was designed to be a great stimulus to the progress of more useful and slower landing aircraft. At least two very advanced aircraft, the Curtiss Tanager and the Handley-Page, very convincingly demonstrated their short-field abilities on both landing and take-off, and yet for almost ten years the aeronautical engineering fraternity only took a slight interest in what these demonstrations had shown. The early development and progress of the Fowler Flap was also delayed and stretched out over many more years than was necessary by this curious blindness in judgment or delay in appreciation by aircraft engineers and their customers of the supreme necessity of doing everything to reduce landing speeds.

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VERTICAL FLYING

At the present time it appears that this need in aircraft development is receiving an increasing amount of serious attention, and there are several areas in which activity may result in quite striking development. The term "vertical flying" is at last coming into serious use in technical discussions. Designs for vertical take-off merely on the basis of jet, rocket, or turbo-prop thrust being greater than the weight, are solutions that are actively being worked on. Then, too, there is a field of promise in a configuration using an "induced" high velocity flow over the wing by a disposition of jet engine intakes and exhaust to give an artificial flow in the slow-speed regime which would greatly increase the lift, even while standing still, greatly reduce the length of take-off and the landing speed, and yet be readily converted from "lift flow" to pure "thrust flow" for very high speed flying.

It was Henry Ford, Sr. who, when discussing aircraft design almost 30 years ago, criticized aircraft engineering very severely for failing to realize that aircraft would really not attain their full development until their power "was used to land with."

SPEED RANGE BY BETTER WING SECTIONS

During this first era of aviation progress, wing sections have been much improved in the range between high lift and low lift and low drag, but there is still much that could be achieved. Speed range (the ratio of high speed to landing speed) in the early first ten years of flying development was considered extremely good if it got as high as two-to-one. In the course of the ensuing 20 years due to improvement in wing sections and finally in the addition of wing flaps, slots, and other high lift developments, there has finally resulted a raising of the speed range to about six- or seven-to-one. In further development to come, our figures are somewhat obscured by having to pass through the sonic range. However, an interesting new development of the last few years which cannot yet be sufficiently appraised is the development of the Delta wing configuration. The range between low-speed, high-lift, and high-speed low-drag appears to be materially further extended with the Delta wing design.

There are other developmental areas in which the extension of the speed range to higher speeds for usefulness and to still lower speeds for practicality, are being worked on.

ASSISTED TAKE-OFF, AND SKIS

Only recently have we begun to hark back to one of the original conceptions of the Wrights.

The original 1903 Wright plane was launched into the air on a small cart riding on a rail with no assist to the take-off. This saved the expense of fixing a smooth field, and saved the weight of a landing gear. Later in their developments, particularly in the many 1905 flights, the Wrights introduced the use of the catapult to assist on the take-offs, and then eventually went to wheels. A long and painful development of landing gears followed through the ensuing 40 years, and finally today, interestingly enough, our concepts are beginning to return to the original Wright conception, with the use of assistance in take-off by either catapult or rocket "jato" assist. Even additional jet engines of small sizes are now being contemplated to give an assist in take-off and when reversed to give a retarding influence on landing. So that we see at least a more determined struggle going on in the engineering development of aviation to compromise the requirement of the highest possible speed for utility with the lowest speed for practicality.

As to the utility of high speed in aircraft, history shows us that there is no question about this whatever. There is nothing more useless than a slow airplane, and the helicopter's slowness in cruising is a burden about its neck that must be removed quite soon in order to make this field really succeed in the long run. Once in the air free of obstacles, all the economics of air transport, all the characteristics so needed by

the military, all the practical usefulness so needed by the individual owner, all bring success to aircraft development only if the item of ever-higher speed is included. And yet, as pointed out, these eminently promising prospects for great future development are hampered initially by the take-off and landing limitations that our present day airplanes require. As the realization of all this is at present dawning upon the brilliant engineers in the industry, we will see shortly—in fact are already seeing—a great deal more attention given to assisted take-offs and catapults. And when we look into this field we find some very surprising conditions.

For example, the Air Force (particularly in the Attack plane and Assault types of air operation), requires very short take-off and landing characteristics. And yet with all the development that the Navy has so successfully demonstrated in its catapult launching and deck landing hook, and wire-engaging retarding mechanisms, it seems only lately to have occurred to the Air Force of any nation to make these the landing systems that they should lay down at a front instead of worrying about long clear runways. If there was ever an argument for a "united" air force, it is this one. And yet if we had ever had a "united" air force, we probably never would have had the Carriers with their landing traps and their catapult take-offs.

Now several advanced designers are beginning to think in terms of fast aircraft of much lighter weight (because they carry no landing gear to speak of) that will take off on a field from either a catapult or a powered launching car and will land on simple skis that will have no extensive roll and no need for brakes that get too hot. And when we do this, it is interesting to see the 50-year cycle reverse itself. Fifty years later we return to the original concept of the Wrights.

WATER BASED AIRCRAFT

While the familiar concrete runway is accepted with a certain finality by everyone, the history of the development of aviation throws this into a considerable question. We have prospects, as indicated above, of developing characteristics in aircraft that will allow the fastest load-carrying kind to land more or less vertically in restricted areas. But we have also in the last few years the development of the jet engine, by which we have ceased to require the use of a propeller. And this has re-opened the entire question of whether we should not use water surfaces as the proper surfaces for aircraft to take off from. In 1907 the Wrights began to get the same idea, and in preparation for some flying around Norfolk over a fleet review—that they were then contemplating—they began work on pontoons to carry their plane. But one of the earliest things they ran into right then was the difficult incompatibility of propeller tips and spray. And this necessity of the clearance of propellers from the water has plagued seaplane design ever since. It is the one item that has caused seaplanes always to be

so ungainly, of greater head resistance, heavier, and because of these, at a disadvantage in comparison to land planes.

But with the advent of the jet engine all this changes. We have a new condition that finds water-based aircraft gaining advantages over land-based aircraft. The jet-engine seaplane does not need any great clearance dimension for propellers, merely a configuration in which the jet intake is reasonably free of spray. The jet exhaust is no problem at all. And as a result, the configuration of a jet-driven water-based

FIG. 7. Required propeller clearance and high center of gravity did this to the World's Record Supermarine Seaplane (1929). Ungainly, head resistance greatly added to, awkward and heavy.

airplane cannot only be fully as streamlined as a land airplane, but is lighter in weight because of not having to carry the heavy landing gear—so difficult to stow anyhow in the thin wings required by high speed. And accompanying this new state of affairs we find today that the development of skis for water landing is achieving a practicality that is very evident. This leads to endowing airplanes with the ability to land and take off rough water to a degree that we have never conceived possible because the skis can be sprung—and incidentally, are very easily folded up into a streamlined body. Demonstrations of the success of this concept have been given in a most convincing manner

by the first public flights of Earl Osborn's Edo ski amphibian, the Convair Sea Dart XF2Y-1, and the All-American ski-equipped land planes.

Lest we get too set in our ways of thinking that airplane usage means land field usage, let us look back into history for a moment and realize that there were two or three different eras in which the speed records of the world could only be won by airplanes that were launched off the water. This was importantly emphasized in the Schneider Cup races, the international events that were held in the late 1920's and early

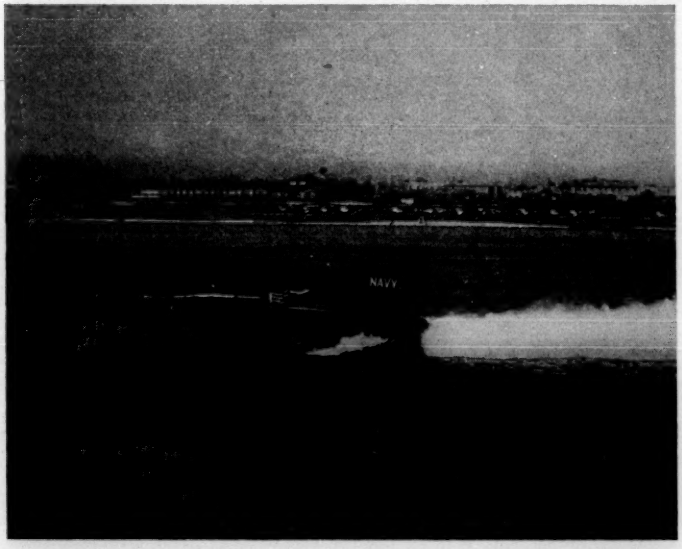


FIG. 8. Jet engines and skis accomplish this change from an awkward float seaplane to a sleek supersonic design that suffers no disadvantage from being water-based, and has many great advantages. (Convair "Sea Dart.")

1930's, in which the speed of land planes was far outclassed by seaplanes—only because of the ability to take off and land on the water surface under conditions of loading and distance that no land area would permit of. Very much the same thing exists today. If our wing sections and high-lift devices were still to limit us to a speed range of somewhere around 6 or 7 to 1 between high speed and landing speed, and if we wished to build the very fastest airplane to win a race from a surface take-off (not air-launching), we should lay down a design that would land and take off at 300 miles an hour and would achieve

FIG. 9. The Loening Monoplane of 1918. The first rigid strut braced wing structure, not widely used until twenty years later.

1800 to 2000 miles an hour in the air. This admittedly would be a difficult job on a land field, non-catapult take-off. But interestingly enough, it would not be difficult on a water-ski seaplane take-off and landing. The only reason that this concept is not as sure-fire as it would have been 25 years ago is that a plane achieving any such high velocity would probably have a thrust greater than the weight and therefore could take off vertically. But it would still have to land, and the vertical take-off would be considerably easier on the water and much less dusty for the observers. We can only sum up this aspect of our 50 years of progress by pointing out that there is still much thinking, devising, and developing to be done on the fundamental problem of how we take off from the earth and how we get back to it

WING STRUCTURES

The configuration of the wing structures of aircraft from the original Pratt truss Wright biplane, has gone through quite a cycle of development, be-fogged by an enormous amount of prejudice, misunderstanding, stubbornness, and lack of sound engineering foresight. Instead of facing the facts of efficient lift and how it could best be obtained, aviators and constructors from the very start to well around into the 1930's got themselves wound up into so much argument as to the relative merit of biplanes and monoplanes that it took no less than 40 years to clear up what was very obvious from the beginning. The reason the

Wrights went to the biplane was perfectly sound and had to do with the question of bracing, of weight limitations, and of a good deal of engineering convenience. But just as soon as air development embraced higher speeds and more power, the reason for the biplane vanished. But—the biplane did not! And all along the era from 1918 for over a score of years thereafter, there still was a stubborn persistence of the biplane form of wing structure. This finally, however, gave way to what we have today—no biplanes in the air in the world excepting a few old-time crates towing advertising banners! This author can derive a very distinct gratification from history on this point because in 1918, con-

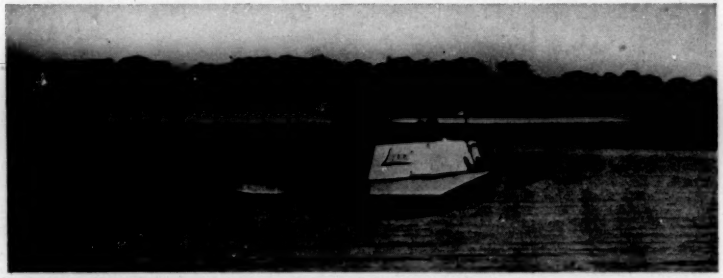


FIG. 10. The Loening Air Yacht of 1921 (Collier Trophy winner). The monoplane structure was strong, simple, efficient but not popular enough yet for acceptance.

vinced of the correctness of the monoplane type, he was almost alone in this country in advocating it, and found the acceptance of the monoplane by the aircraft industry's customers so difficult and so surrounded with prejudice that in 1923 he was forced to make the Loening Amphibian a biplane for no other reason than to sell it. The greater lift of the monoplane due to the lack of interference of one wing with another, the considerably lower head resistance, and the lighter weight, won out in the end over the fancied objections that had been harped upon for so long. The untenable anti-monoplane sales talk was that a monoplane was unstable, structurally weak, and too "tricky" in maneuvers. The simplicity of the monoplane structure insured its survival—particularly of the type, referred to above, with a simple strut bracing, which type 20 years later came into very general usage and still is seen in the Cessnas, Cubs, Beavers, etc. Of course, eventually the struts have been superseded by the cantilever monoplane structure that is now so nearly universal. A quotation is given here from a treatise on this subject by the author, "Revival of the Monoplane," written in 1919, which perhaps has a message to give:

Aeroplane designing is merely a series of extraordinary compromises that have to be hit upon with a rare judgment because in general all aeroplane features fight each other—weight needed for strength reduces flying performances, roominess for convenience requires a sacrifice to head resistance, etc., so that the competent engineer must constantly balance these opposing features. If he brings out a triplane, let us say, just for the sake of making it a triplane because other machines are biplanes, without having very clear and logical reasons for doing so, he fails in his true mission. The ideal features that we are looking for in the aeroplane structure itself are (1) light weight—the most important of all—(2) the combination on a machine of stability (meaning ability of the plane to stay where it is put along its course), combined with easy controllability (which means a quick, positive response to all controls) —this is perhaps the hardest feature to develop in a new plane; (3) the desirability of simplicity of construction, which almost always bring light weight with it, and finally (4) we seek a low head resistance, obviously, so as to get our best performances.

No matter what purpose an aeroplane is designed for, be it a large bomber or a small scout, a waste of weight is little short of criminal in aeroplane design, and complication, it is well known, is usually evidence of bad engineering. In fact, the whole essence of really good engineering is simplicity.

But it took the aircraft industry almost 30 years to learn the above lessons in the configuration of wing structures. And yet such lessons and precepts were exactly what Orville Wright taught.

FIG. 11. The Loening OL8 Amphibian. This widely used biplane was typical of accepted wing structure in the decade of 1920 to 1930 carrying around all its life two hundred pounds more weight and fifteen miles an hour less high speed than if it could have been a monoplane.

ENGINE LOCATION

Engine location was, of course, another problem of configuration for aircraft designers which followed prejudices and fashion a good deal more than sound engineering sense should have allowed in these 50 years. The pusher installations at the beginning were convenient structurally and supposedly more efficient. In the case of the single propeller direct drive installations like Curtiss, this was later to be proven wrong, because the efficiency lost by the added resistance of the faster tractor slip stream on the fuselage was regained by added lift on the wings. This had apparently been appreciated much earlier in Europe than in this country, because in the 1907 to 1914 era the

FIG. 12. The 1909–1912 Curtiss "pusher" engine and radiator directly aimed at the pilot in case of a crash.

development of the tractor fuselage airplane in Europe was far ahead of what we had in this country. It is remarkable that in the case of both Wright and Curtiss we persisted so long in this unsatisfactory pusher type because, of course, of the great danger in many minor accidents resulting in fatalities. The engine often fell out on the crew, due to the light weight structures that were then needed, in order to get into the air at all. Probably one of the reasons for this "pusher" persistence was that for exhibition flying there was great merit in the public being able to see the aviator completely exposed, sitting on his perch at the leading edge of the wing with no protection from the wind whatever. Even Orville Wright succumbed to the tractor configuration

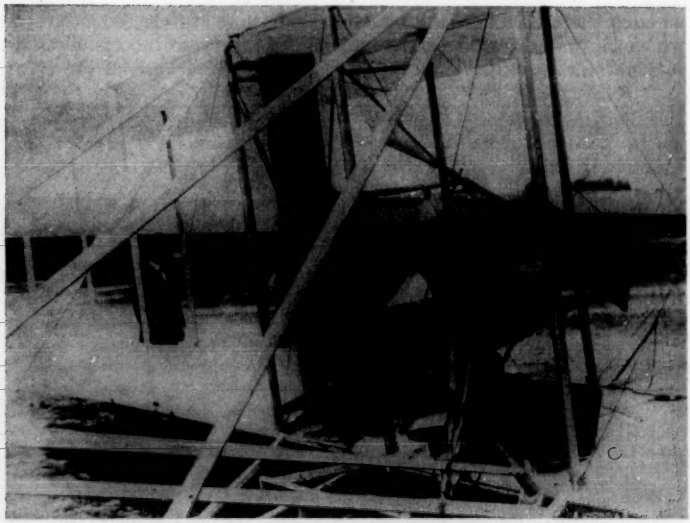


FIG. 13. The early Wright Model A—1909—engine configuration, engine to side of pilot and vertical radiator.

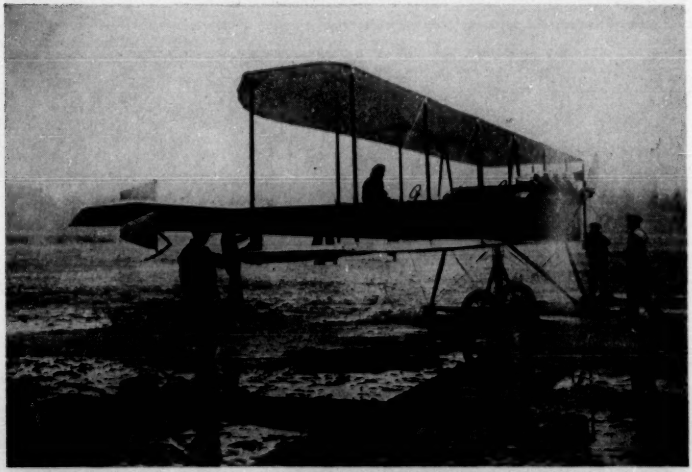


FIG. 14. An early French innovation that marked the start of an era. The "Astra" tractor of 1911, with Wright biplane wings on a covered fuselage with Renault tractor engine and propeller.

when in 1916 he brought out his Model H enclosed fuselage tractor-type which Howard Rinehart flew around the country so successfully. In seaplanes, the pusher type quickly succumbed because of the spray

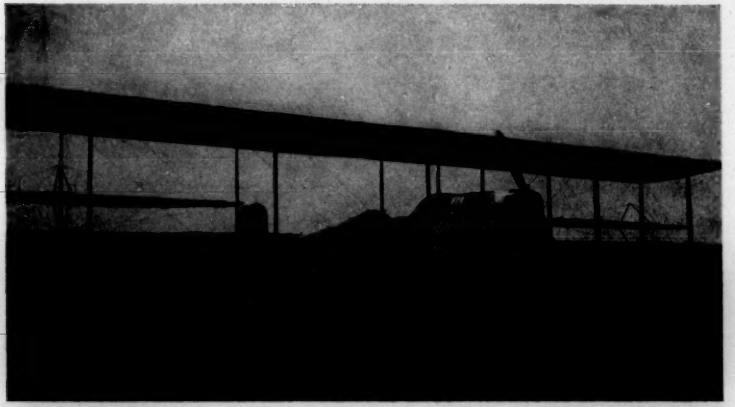


FIG. 15. America's first highly successful tractor type. The Glenn Martin training plane of 1913. Note useless skids and nose wheels on the landing gear; also ailerons between the wings.

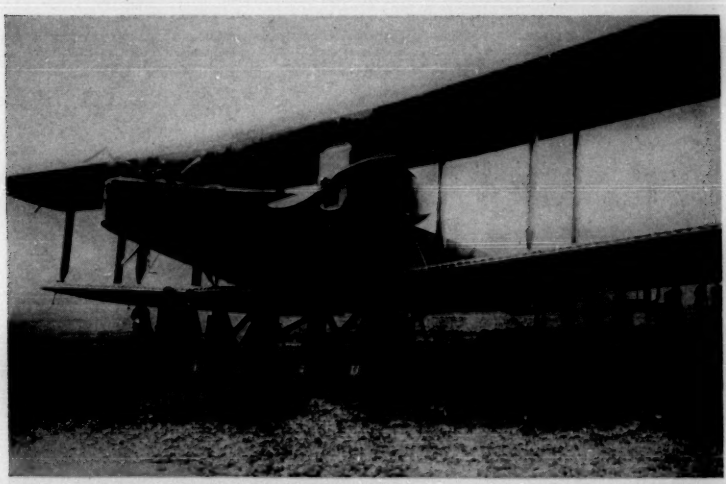


FIG. 16. The Handley-Page of World War I. This widely used twin engine plane typifies the configuration of engine between the wings at this early stage.

thrown into the propeller, and the tractor type was even more advantageous there. Then, of course, as we progressed, we got to multi-motored aircraft with the engines at first mounted between the biplane wings (a most inefficient configuration), and then finally with the engines as we see them today mounted integral on the monoplane wing. It is interesting to note that this efficient, correct, and simple type has survived as an element of configuration on aircraft for almost 30 years. In this country, of course, the early Boeing 247-D and the Martin bombers of the early 1930's were the eminently successful forerunners of this later-to-become-universal twin-engine configuration.

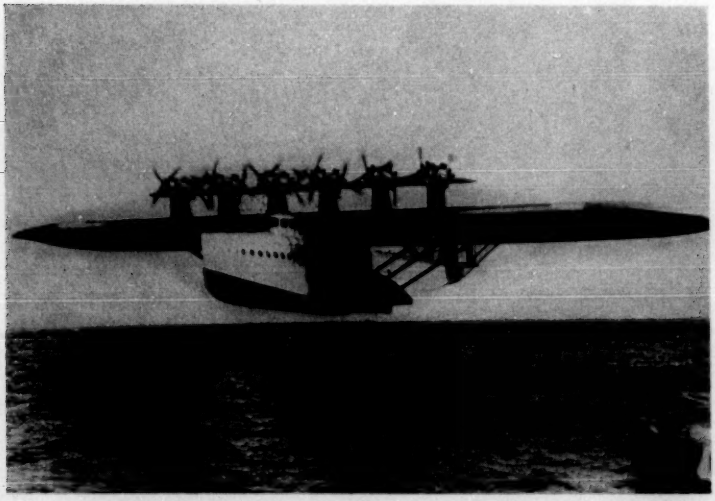


FIG. 17. Engine location gone mad. The DOX Dornier twelve-engine flying boat of the early 1930's.

During the arrival at this final type we also went through a tri-motor period, notably the ubiquitous Ford tri-motor and the Fokker. But this type did not last except for the Fords, which of course, were more widely used and probably one of the most successful airplanes in history.

STABILITY AND CONTROLS

Fifty years have done much to the airplane's control surface, stability, and tail configuration. Re-examining the early Wright plane from the standpoint of our present-day knowledge, we first must pay tribute to the acrobatic balancing skill that they had to have in order

to keep the airplane flying straight. The "Kitty Hawk" was controllable all right, but completely devoid of any natural stability. This applied also to the early Curtiss planes. And while on the subject of controls and stability, we should make it clear that it was in this area that the Wright invention really counted so effectively.

To begin with, the Wrights and Spratt who aided them, made a discovery in their early gliding experiments for which ample credit is never given. They were definitely and distinctly the first ones in the art, here or in Europe (and this included Lilienthal and of course Langley), who found out and verified by test that the center of pressure

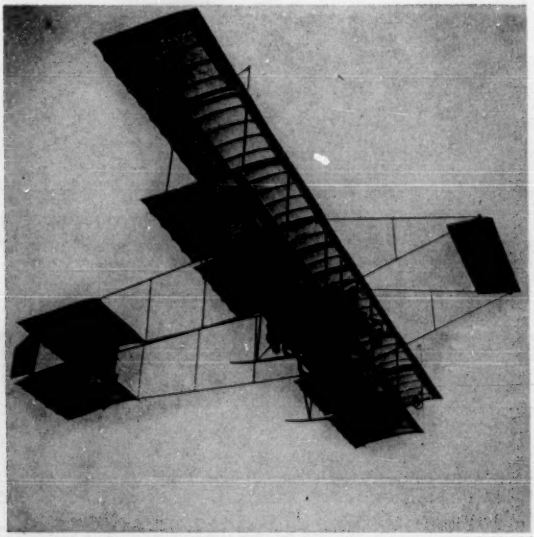


FIG. 18. Farman 1910 to 1912 pusher biplane showing the trailing edge ailerons (instead of warping wings), forward and aft elevator. Note also skid landing gear.

on a curved surface moves *backwards* when the angle of incidence is decreased. All other experimenters had thought that the center of pressure acted as it did on flat plates and moved forward. The Wrights also verified this in their wind tunnel experiments, and incidentally, Wilbur Wright mentions this in his famous paper before the Western Society of Engineers in 1901. Center of pressure location enters with fundamental importance into the question of stability, because the knowledge of this enabled the Wrights to balance their plane correctly and to arrange their longitudinal up-and-down control to operate properly. Then, of course, the basic Wright invention on which they

received their patent was their lateral control of roll. They put into practice the realization that up-and-down control and side-to-side control by rudder were not enough for successful flying, and that a third control was needed to balance laterally in roll.

The Wrights first incorporated lateral control in their airplanes by the well-known lateral twisting or warping of the wings. When they did this, of course, the side that had the greater angle of incidence, and would therefore raise up, would at the same time have a greater drag and therefore would require compensating rudder action. This was where the Wrights combined the directional yaw and the lateral roll control into one movement, although in later types of other constructors like Curtiss, pilots learned to do this as part of their training.

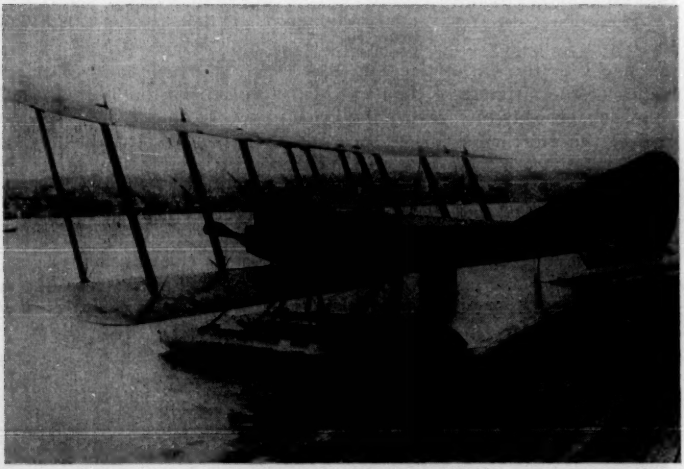


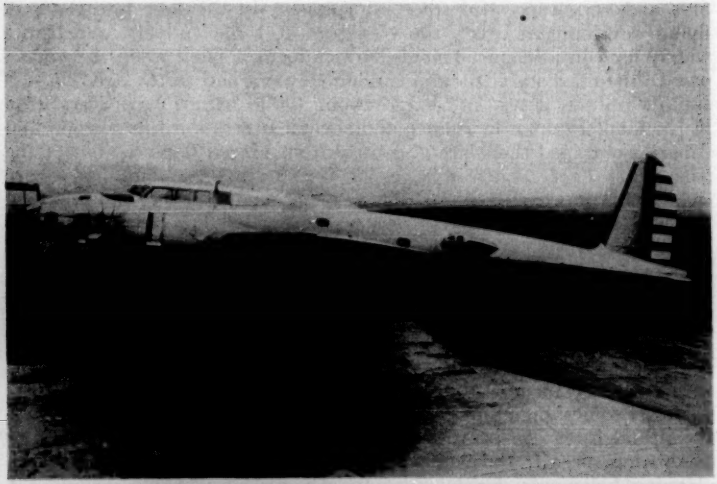
FIG. 19. An early Boeing training plane. Note low rudder, small fin, short tail length, no stabilizer. This was typical of the 1910 to 1914 era.

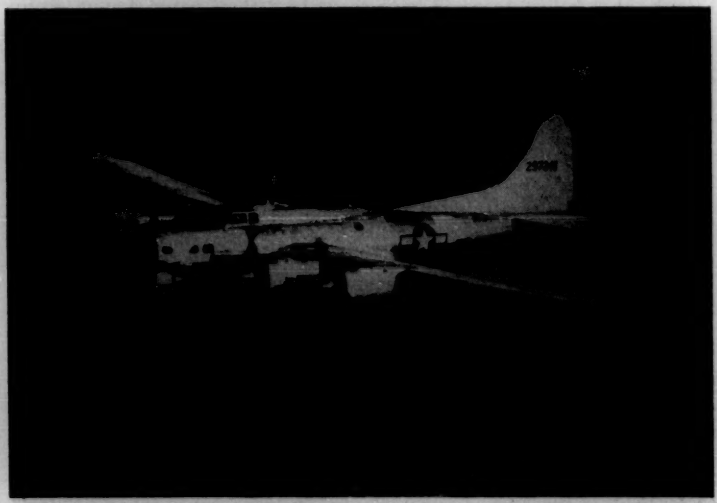
As we progressed into the tractor type with a fuselage, the fuselage gave considerable directional fin area, and the very earliest enclosed fuselage types like the Nieuport had a quite low small balanced rudder at the end, so that they still required a great deal of coordinating of the lateral and directional controls. But as our 50 years progress, we find the combined rudder and fin area becoming larger and higher, and finally in the modern airplane of today so high that much lateral balance is obtained from the rudder and fin alone, and the necessity for coordination on a really good modern airplane has more or less ceased to exist. We have excellent planes that turn very nicely on ailerons and equally good ones that are corrected laterally on fin and rudder alone. Tail

length has also gone through an ever-lengthening development. The "Kitty Hawk" was very short tailed—of course it had the front elevator, a questionably stable layout, which was in short order replaced by a horizontal tail in the rear with a much greater lever arm. But as we go down through the years we find tails of good aircraft becoming longer and longer, and larger and higher, and as we are about to wonder when this will stop, along comes the Delta plane design and brings us abruptly to a halt. Of course modern wing sections have been developed that have a very much smaller and more stable center of pressure movement. And this makes the shorter Delta wing configuration much more feasible. The Delta wing still looks as if it will continue to have large fin and rudder areas with considerable leverage around the center of gravity.

There have been two body configuration developments through these years slightly different from the natural growth of the covered fuselage into the enclosed cabin, and into the large, roomy interior bodies of the airliners of today. One, of course, is the Burnelli and Northrup projects of carrying the loads in a very thick wing. In the case of the Northrup, this was carried even further into the "flying wing" type where there was no tail at all. But as the "flying wing" developed, what amounted to tails began to be added to the wing tips, giving lateral and directional control leverage around the center of gravity, introducing the complication of added surfaces and the weight of controls and their stresses. Whether for this or other reasons, the tailless airplane has not survived, and not even in the case of the Delta wing can we consider that it has survived because the successful Deltas have such large fin and rudder tails. The other differing configuration is the twin boom holding tail structures such as in the Fairchild Packet and the new "Nord Atlas" in France. There is a sound reason for this twin boom design that has nothing to do with either controls or stability. It is the excellent way in which this configuration allows for a cargo-carrying body with accessible doors very conveniently arranged for loading or parachute-load dropping. The excellence of this configuration as being sound is all the more accented when one contemplates other cargo types that have a large swept-up fuselage with a very high tail, the strength of which fuselage is tremendously weakened by the cutting out of a large door right in the center where torsional strength is needed. So that to resist tail flutter and carry the high tail twisting loads, a very heavy fuselage framing is needed to make up for the door hole weakening.

As soon as the wing warping lateral control system used by the Wrights and by Bleriot disclosed how it weakened the wing structure and what heavy loads it put on the control system, it gave way to the use at first of separate surfaces in between the two wings like the early Curtiss Ailerons and the ailerons that Glenn Martin mounted on his





FIGS. 20 and 21. Typical of tail surface control development are these views of the Boeing B17 bomber. The upper one shows the original and the lower one the final model at the end of World War II six years later—a constant increase in fin area and rudder height.

first and very successful tractor airplane. In the first few years of flying development, even the elevators and the rudders were quite widely used in a balanced single surface form. Then when these gave way to the fixed stabilizer and trailing elevator and to the fixed fin and trailing rudder, it was not long—about 1909—before Moore-Brabizon in England, Farman in France and several others both in Europe and America obtained their lateral control from hinged flaps cut out of the wing tip. These controls have survived ever since, and had every right to continue to survive as they were eminently correct and practical and were easily modified to have mass or aerodynamic balances so that they could grow to large size and still be workable.

However, as soon as we entered the trans-sonic and supersonic area of flight, aircraft controls by movable hinged surface areas became open to a great deal of question. Lateral control had already been toyed with in the form of spoilers that would reduce the lift on one side only. But the problem of control in the supersonic region still remains. It is fairly certain now that control by hinged flap is apt to be superseded by something else.

Although we are principally concerned here with our 50 years of fixed wing aircraft development, control and stability problems are plaguing helicopter development to a very considerable degree. It may be that helicopters will have to go to a three-rotor system giving three points of control like the two wings and the fixed tail of the Wright airplane and then merely vary the thrust of the rotors against each other to get any combination of control forces around the three axes.

LANDING GEARS

The landing gears of aircraft have gone through a complete cycle in these 50 years. The Wrights started with skids alone, and the hottest new designs of aircraft today again look like skids alone. The story of this metamorphosis is about like this: The Wrights started with skids alone, because their feeble craft could not carry the added weight of wheels, nor had it enough horsepower to overcome the wheel friction, and the landing on skis was simple and effective and short. Then, as their power grew greater and the Model B developed from the original 12-horsepower to the 30-horsepower class and their power-loading went down to 40 pounds a horsepower, wheels were feasible and were merely added to the then-existing skids. Then for many years landing gears of airplanes all over the world, with one outstanding exception, were always a combination of wheels and skids, the theory being that if the wheels failed, the skids would save the works. The one outstanding exception was Bleriot in France who never had any use for skids at all. In those early days we soon discovered that many a landing resulted in an accident, not at all because the wheels failed, but because the skids

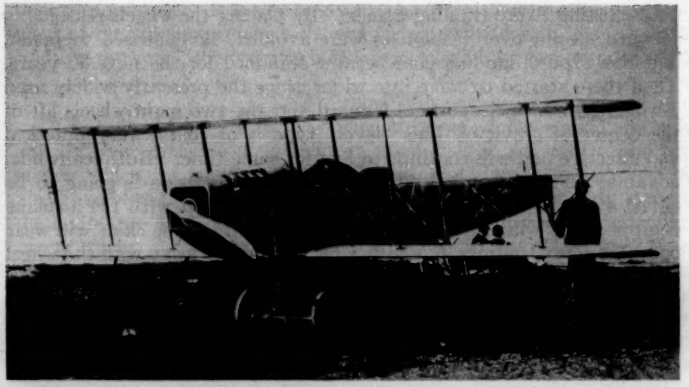


FIG. 22. This 1913 Curtiss tractor had a typical landing gear of skids and wheels. On a hard landing the skids would break and turn the plane over.

broke, dug into the ground, and turned the airplane over. So some of us here proposed and put into effect the simple 2-wheel and tail skid landing gear which was first introduced at North Island by the author in 1913 and incorporated with a great saving in weight on several

FIG. 23. The first American simple two wheel and no forward skid landing gear shown here was built by the author in San Diego in late 1913 and later adopted for all Army aircraft.

then-existing Army training planes. By placing the wheels reasonably forward, nosing-over tendencies were avoided, skids ceased to break, and this type of landing gear became standard for the next 30 years. Then there started to come into wider usage the presently widely used 3-wheel gear with nose wheel forward and the two main wheels aft of the center of gravity. This "level" type is of course very practical and effective and will continue to last for some time. But meanwhile, advances continue, and the next step in landing gears is going to be either a catapult track or a dolly truck for take-off with the airplane equipped only with skids to land on. To be sure, these skids will wear out after many landings, but so do tires. By doing away with the wheel and the tire we not only shorten the landing, but we do away with

FIG. 24. The practical retractible gear of the amphibian in 1923 to 1926 led to a much wider adoption on land planes.

complicated braking systems and with a heavy weight of wheels and with what is even more serious, the difficulty of stowing wheels in the thin wings that our higher speed regimes now demand. Of course there is another advantage—the ski landing gear can take off the water, can land on snow, can land on mud, and if we finally do get to vertical take-off aircraft as we are very likely to soon in great quantities, the wheel gear will disappear excepting for small rollers for convenience in handling on the ground. And thus we will get back to the ski-equipped airplane that the Wrights started with 50 years ago.

During the landing gear development of this era, it is surprising to note how tardy and stubborn and backward most aircraft constructors were in adopting retractible landing gear configurations to improve

their performance. It is safe to say that had it not been for the development of the amphibian which showed the ease with which landing gears could be retracted, the progress in this area would have been even slower.

POWER PLANT FORMS

The types of engine forms during this period have gone through equally ever-changing development until finally we get to the jet engine which, of course, is a totally different departure. Propellers also have been the subject of much development since the early Wright days, and we should therefore consider them jointly as the effective power plant. The Wright's original solution was little less than inspired. With all the knowledge that we have today of propellers and of power plants, given the materials of construction, the technique available, and methods of manufacture, the Wright's solution for turning BTU's of gasoline into effective driving thrust for flying could not be improved upon. The Wrights approached their propeller design from the correct standpoint of considering their blades rotating airfoils, and their calculations and method of design are still today an outstanding tribute to their engineering and scientific abilities. In this designing region they really had very little to go on, excepting some marine screw propeller theory, much of which they quickly discarded. While they of course had a power loss between the engine and the propellers due to the chain drives and sprockets and extra shaft bearing frictions, this was all more than made up for by the fact that their two large propellers were giving a very high order of efficiency at their flight speed of 30–40 miles an hour. This they could never have obtained if there had been only one little direct drive propeller on their little 12-horsepower engine. Also, the Wrights had the good sense to eliminate torque as an added complication to their stability and control problems by having their propellers turn in opposite directions. As the years grew on, however, and the power of engines became ever greater—and the power of controls also became ever greater—torque was not too great a problem other than on take-off. But from the efficiency standpoint, the value of geared-down, large-diameter propellers is becoming increasingly impressed upon us even today by such advanced planes as the Helioplane of Koppen and Bollinger. The slow progress of including in propellers the added efficiency item of variable pitch, took years to get into the picture because of the same strange unwillingness of aircraft engineers to move, even though the signposts of where progress is leading are sometimes so clear. The propeller construction of the Wrights was of wood with fabric covering to protect the wood from splitting too easily when hit with stones from a field. These wooden propellers were soon found to suffer from humidity and other variations so that they were gradually succeeded by metal construction, first of a steel hub with aluminum blades, and then steel blades, and of late some new plastic developments of great interest.

Engines themselves started out in a flat pattern with the Wrights. And then they put their four cylinders into an upright model with the crankshaft low, and in Europe there was an early start on the first radial air-cooled engine. Then came the tremendously successful Gnome rotary engine, and then both in Europe and in America the further tremendous development of the large radial air-cooled. During the development in use of the water-cooled upright engine like the Liberty, it became increasingly apparent that whereas the Wrights had good reason for the upright engine in order to have their chain drive mount on the wing, the later water-cooled tractor types for aircraft should have started out right then and there as inverted engines with the crankshaft high, in order to give maximum propeller clearance for minimum body height. And looking back at this era, it is very likely that this would have been the case had automobile engineers not been so intimately identified with water-cooled aircraft engine development.

In radiator cooling for water-cooled engines, our 50-year era had a problem that was never properly solved excepting by the advent of the air-cooled engine. Even in war planes the liquid-cooled engine had its greatest disadvantage in the ease with which one bullet could wreck all by hitting the radiator, whereas an air-cooled engine could have several cylinders beaten up without having to stop at once. Radiators through these years assumed all manners of shapes, sizes, and configurations. They were placed in front of the engine, behind the engine, above the engine, slung underneath, formed into wing surface contours, and so on. The Wrights started out with a simple vertical combination of standpipes that had a large cooling area for the water volume and—a very important item—a large gravity head over the water pump. The weight of water cooling was mitigated somewhat in later years by the use of chemicals for cooling, but the extra plumbing and the extra weight and the extra drag always remained. And there were many sighs of relief when air-cooled engines came into such great usage, just as there are sighs of relief now that we enter into the jet era, with a simple, easy-to-install power plant.

MATERIALS OF CONSTRUCTION

The materials used in construction of aircraft have, of course, varied considerably down through the years. At first silver spruce was the backbone of aircraft construction used by the Wrights and others in wing spars, struts, ribs, etc., with ash used for the skids as it was a much harder wood. But the generally unsatisfactory nature of wood, the difficulty of getting homogeneous pieces of the same weight and even of the same strength that could be relied on, the many kinds of weather and humidity effects that would affect the strength or alignment of the structure, were all headaches that quite naturally led, both in Europe and in this country, to a search for metal construction. At first this was

considered altogether too heavy. But it was not long before very thin high alloy steel tubings gave a weight ratio to their strength that was satisfactory. While at first the joints were made with fittings and then later were brazed and soldered, the Fokker type of welded tube construction came into wide usage, particularly in the framework of fuselage and tail surfaces. At first wing surfaces were covered with oiled silk or rubberized fabric, both of them most unsatisfactory materials subject to tension variations under different weather conditions. This was followed by the doped linen or cotton era. Then plywood

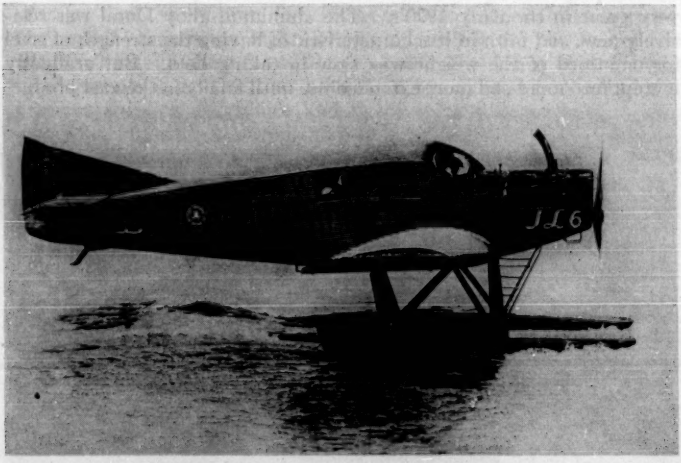


FIG. 25. The Junkers all metal aircraft of 1920 to 1930 was the direct forerunner of how we build planes today.

began to enter the field particularly in some very fine workmanship samples such as the beautiful Antoinette monoplane built in France. And whereas plywood was used for the covering of fuselages such as introduced in the monocoque by Deperdussin in 1912, it was not until towards the end of the First World War that Fokker appeared with cantilever wings of thick section with wooden beams and plywood covering that took the torsional strains. This was a good deal of an innovation in aircraft structures and pointed unerringly towards the future, but at the time was not adopted very widely.

These wooden cantilever plywood wings were of course also subject to the weathering effects on wood—the drying out in the sun, the inability to stand too much moisture, the questionable strength of glued joints subjected to extensive weathering or vibrations. The

forecast of things to come on aircraft structures was given by the Junkers all-metal cantilever wing monoplane which made in Germany what was later to be a world-wide appearance, around 1921. This step was marking the final death knell of the wood-frame, wire-braced box kite of the Wrights and their later contemporaries like Farman in Europe. But for a period of almost 20 years the aircraft industry still persisted, and their customers still insisted on their building this unsatisfactory type of aircraft structure, making it a long process before the Junkers of 1921 became the Strato-Clipper of 1951.

The prejudice against aluminum in structural parts of aircraft was very great in the early 1920's. The aluminum alloy Dural was relatively new, and faith in its characteristic of having the strength of steel for one-third of the weight was slow in taking hold. But gradually it crept into more and more extended use until finally in the vast produc-

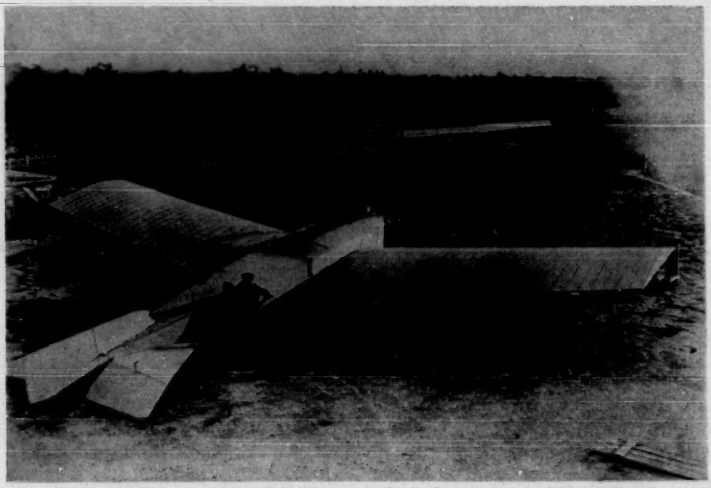


FIG. 26. Forty years ago this highly streamlined, Cantilever wing "Antoinette" monoplane pointed the direct path to our present day, but was ignored.

tion era of World War II, all-metal Dural riveted and welded aircraft construction proved itself out in the tool room, in the production line, and in combat, so that it became the universal method of building aircraft. This type of construction is threatened today by the advent of magnesium on the one hand, still lighter and with many qualities in its favor, with several different kinds of glass and plastic resin materials that have excellent qualities to recommend them for aircraft structures, and finally by the advent of that great new metal, titanium, which has all the qualities that we need excepting that there is not enough of it.

There is no doubt that the field of alloy metals for aircraft will, from here on out, be subjected to great improvements and modifications which might even include some mutation of crystalline structures by virtue of atomic radiation or isotope application. Since we have been at this fundamental of light metals of great strength for aircraft work only 30 years, we can look forward to as great changes in the next two or three decades as we have had in the past.

CONCLUSION

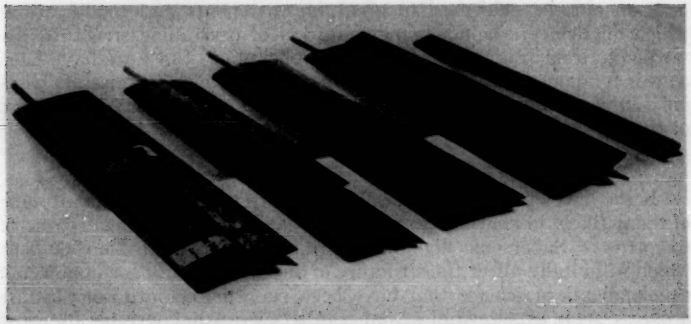
Is the development from the Wright "Kitty Hawk" to the airplane of today likely to continue to bring as great a change in the airplane of tomorrow? Supersonic flight is bringing with it the problem of heat which will vitally affect the structure of aircraft. Many accompanying developments in science that have been coordinated into our aircraft progress such as electronics and gyroscopics will continue to grow greatly in importance, so much so that we are entering an era where tricky flying qualities requiring an expert acrobatic aviator to handle will give way to automatic devices. These will reduce the fastest flying, as far as the pilot is concerned, to such simplicity that an older man with poor eyesight could handle the aircraft fully as well as the present stunt pilot can. Autopilot and automatic stability machinery can fly far more accurately than even the best pilot can do.

Then we have the era of vertical rising of aircraft coming in where even the fastest design will cease to need these expensive enormous landing fields. We will recognize that flying consists of two regimes —the take-off and landing in a practical manner near the objective, and then the highest possible speed between terminals.

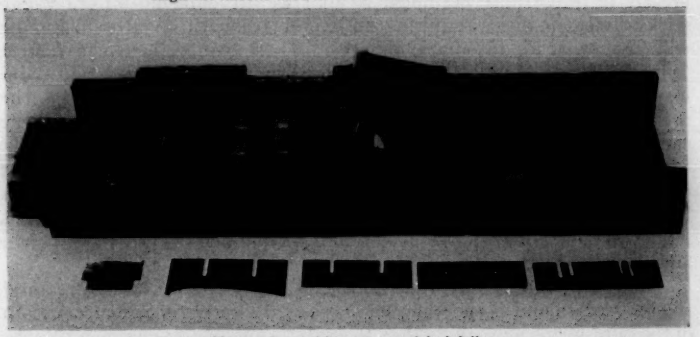
One item in our development that has been more or less ignored these 50 years and is plaguing us now very greatly, is the suppression of the outrageous noise of modern aircraft. The piston-engine airplanes are bad enough, but the present jet configurations are even worse. And unless we can overcome this, the vast development of the aircraft field that awaits it—particularly in the private vehicle field—will be greatly restricted.

The concept of the Wrights has grown to full stature. It has endowed mankind with a mobility that was undreamed of. To be sure, it has not changed the difficult nature of human nature, but it has promise,—by virtue of its very terrible potentialities in war,—of forcing the world to find more peaceful means of getting along together. So that after all, the Wrights' original hope that this invention would not always be dedicated to war may finally turn out to be happily resolved by its more prosaic success and wide usage for peace.

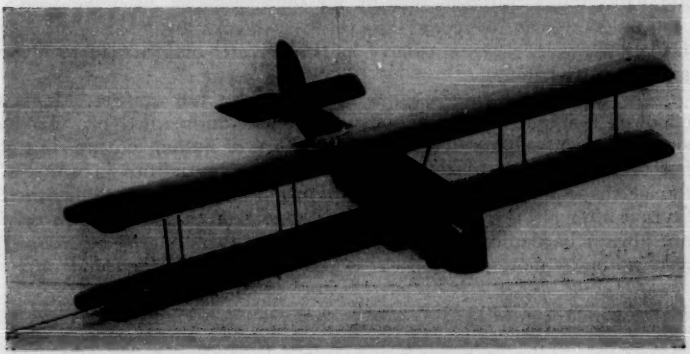
Some material from the Wright Collection at The Franklin Institute



High lift airfoils used in 1921–1922 wind tunnel tests.



Shaper for making wax model airfoils.



Wind tunnel model of biplane with split flap.

MEDAL DAY PROCEEDINGS AT THE FRANKLIN INSTITUTE

October 21, 1953

The annual reception, dinner, and presentation of awards, known as "Medal Day," took place at The Franklin Institute on Wednesday, October 21, 1953. The reception began at 6.30 P.M. and dinner was served at 7.10 P.M. Mr. S. Wyman Rolph, President of the Institute, presided at the dinner and presented the subsequent awards.

RECEPTION

The usual reception preceded the dinner and was attended by approximately 425 persons. Immediately following the reception and just before dinner was served in Franklin Hall, Mr. Rolph requested the guests to face the flag above the Franklin statue while Mr. Guy Marriner, director of music at the Institute, played the National Anthem.

INVOCATION

The Reverend Andrew Mutch, Minister Emeritus of the Bryn Mawr Presbyterian Church, delivered the invocation.

* * *

Mr. Rolph extended thanks and appreciation to the members of the Hostess Committee of The Franklin Institute for their able assistance and for their kindness in providing the beautiful floral decorations. Dinner was then served.

TOAST

MR. ROLPH: "Ladies and gentlemen! It is our custom on Medal Day to pause for a moment in the proceedings to salute the man this great institution was founded to honor. I propose a toast to Benjamin Franklin."

* * *

MR. ROLPH (*continued*): "Now, we shall adjourn to the Lecture Hall, on the floor beneath this, and proceed with our Medal Day ceremonies. There are stairs to the ground floor and Lecture Hall through the bronze gates on the far side of the hall. Elevators are just beyond these pillars. We will resume our meeting in the Lecture Hall in ten minutes."

ADJOURNMENT TO LECTURE HALL

MR. ROLPH: "Honored Guests, Fellow Members of The Franklin Institute, and Friends:

"On behalf of The Franklin Institute, and as its President, I extend a warm welcome to you on this memorable occasion—the presentation of the medals for 1953 by the Institute."

STATED MONTHLY MEETING

MR. ROLPH: "Today, Wednesday, October 21, 1953, marks the first stated monthly meeting of The Franklin Institute since May 20, 1953. The minutes of that meeting were published in the June issue of the JOURNAL OF THE FRANKLIN INSTITUTE. If there are no corrections or additions, I declare them approved as printed.

* * *

MR. ROLPH: "Tonight we have with us many former recipients of the Medals presented by The Franklin Institute. It is a great honor for us to have them here. We should like you to know them. Colonel Hiram B. Ely, who is Chairman of the Committee on Science and the Arts, will read their names and announce the award each has received. As he does so, will each Medalist please rise and remain standing until the list has been completed? Until all of our former Medalists are standing, will the audience please withhold your applause?"

COLONEL ELY: "Former Medalists with us this evening are:

FORMER MEDALISTS ATTENDING MEDAL DAY—1953

Year	Medalist	City	Award
1902	Myron Francis Hill	Westport, Conn.	Certificate of Merit
1903	G. H. Clamer	Philadelphia, Pa.	Cresson
1911	Joseph S. Hepburn	Philadelphia, Pa.	Longstreth
1921	Joseph S. Hepburn	Philadelphia, Pa.	Certificate of Merit
1915	Charles D. Young	Philadelphia, Pa.	Longstreth
1948	Charles D. Young	Philadelphia, Pa.	Henderson
1916	J. V. N. Dorr	New York, N. Y.	Scott
1921	L. H. Adams	Washington, D. C.	Longstreth
1921	W. Barton Eddison	Ardsley-on-Hudson, N. Y.	Longstreth
1922	Joseph F. Keller	New York, N. Y.	Longstreth
1923	Harry S. Parks	Pottstown, Pa.	Longstreth
1927	James F. Smathers	Poughkeepsie, N. Y.	Longstreth
1928	Frank N. Speller	Pittsburgh, Pa.	Longstreth
1928	William C. Taylor	Corning, N. Y.	Potts
1932	Thomas R. Harrison	Wyncote, Pa.	Certificate of Merit
1934	E. Newton Harvey	Princeton, N. J.	Wetherill
1936	Peter P. G. Hall	Philadelphia, Pa.	Longstreth
1937	Rupen Eksergian	Media, Pa.	Henderson
1945	Rupen Eksergian	Media, Pa.	Levy
1937	John S. Haug	Philadelphia, Pa.	Longstreth
1938	Stewart S. Kurtz, Jr.	Merion Station, Pa.	Levy
1939	E. Burke Wilford	Merion, Pa.	Certificate of Merit
1942	Jerome C. Hunsaker	Cambridge, Mass.	Franklin
1942	Walter Larkin	Norristown, Pa.	Certificate of Merit
1944	Joseph B. Ennis	Paterson, N. J.	Henderson

Year	Medalist	City	Award
1944	Walther E. Mathesius	Chicago, Ill.	Clamer
1945	Walter J. Coppock	Moylan, Pa.	Certificate of Merit
1946	George C. Southworth	Chatham, N. J.	Levy
1947	George S. Southworth	Chatham, N. J.	Ballantine
1947	Karl P. Billner	Philadelphia, Pa.	Brown
1947	Kenneth S. M. Davidson	New York, N. Y.	Wetherill
1947	Peter J. Mulder	Shippensburg, Pa.	Certificate of Merit
1947	Sedgwick N. Wight	Rochester, N. Y.	Henderson
1948	Nicholas F. Arone	Upper Darby, Pa.	Longstreth
1948	William H. Cherry	Princeton, N. J.	Levy
1948	Clarence A. Lovell	Summit, N. J.	Potts
1949	John W. Mauchly	Ambler, Pa.	Potts
1951	Samuel A. Greeley	Chicago, Ill.	Brown
1951	Jean Mercier	Paris, France	Certificate of Merit
1952	Walter H. Brattain	Murray Hill, N. J.	Ballantine
1952	Harrison P. Hood	Corning, N. Y.	Wetherill
1952	Edward C. Molina	East Orange, N. J.	Cresson
1952	Martin E. Nordberg	Corning, N. Y.	Wetherill
1952	Albert J. Williams, Jr.	Philadelphia, Pa.	Wetherill

"The following companies, which have received medals, are also represented this evening:

REPRESENTATIVES OF COMPANY MEDALISTS ATTENDING MEDAL DAY—1953

Year	Company Medalist and City	Represented by	Award
1900	A. J. Holman and Company Philadelphia, Pa.	William K. Holman	Longstreth
1902	Williams, Brown & Earle, Inc. Philadelphia, Pa.	Peter Abrams	Longstreth
1906	Colt's Manufacturing Company Hartford, Conn.	George A. Webb	Longstreth
1909	Underwood Corporation New York, N. Y.	Donald S. Sammis	Cresson
1910	Automatic Electric Company Chicago, Ill.	Percy G. Black	Cresson
1916	The Sharples Corporation Philadelphia, Pa.	L. P. Sharples	Longstreth
1922	Remington Rand, Inc. Stamford, Conn.	P. E. Almquist	Longstreth
1941	United States Navy Washington, D. C.	J. H. Brown, Jr.	Cresson
1944	Western Union Telegraph Company New York, N. Y.	N. P. Corwith	Certificate of Merit

MR. ROLPH: "Thank you, gentlemen. Thank you, Colonel Ely.

"At the regular stated meetings of The Franklin Institute, it is the custom to call for the Secretary's report. Dr. Henry Butler Allen is Executive Vice-President and Secretary of the Institute, and I now call on him for his report. Dr. Allen."

REPORT OF THE SECRETARY

"The Institute in 1953"

DR. ALLEN: "Mr. President, Distinguished Guests, Ladies and Gentlemen: Each year in preparing this Secretary's report, I have the opportunity of refreshing my mind about the progress that The Franklin Institute has realized in the foregoing twelve months. Very often, being in the midst of the activity, one is inclined to see only the matter at hand, but looking back at the whole experience can indeed be very enlightening. Let me briefly list some of those things that have happened here so that we can share this pleasure of retrospection.

"The Museum, that part of the Institute best known to most people because of their direct contact with it, continued its popularity, and service to the schools. I want to stress our help to the school children. There have been changes within the Museum itself—and more changes are in prospect as we can get financial support. The old Chemistry Room is completely altered. It now houses an enlarged petroleum exhibit made possible by the Sun Oil Company. Already visited by many thousands since its opening, it is also used by the Sun Oil Company as an instruction and orientation medium for its personnel and dealers. The remainder of the Chemistry Section is being redesigned as a basic chemistry exhibit room. And nearby is a new exhibit on steelmaking, from Bethlehem Steel Co. In addition to these exhibits already open to the public, others are in prospect. An extensive exhibit about the heart will soon be opened, whose central feature will be a model heart so large that our visitors will be able to clamber through it, following the course of blood and feeling it beat out its life-giving rhythms. The Curtis Publishing Company is fast completing a new exhibit in our Graphic Arts Room, telling the story of a magazine—how it is prepared, printed and distributed to you, its readers. The International Nickel Company will open an exhibit of the precious platinum metals next month on the 150th Anniversary of their discovery. Philadelphia's Edward G. Budd Company, a name that has been heard here in The Franklin Institute for some time, is working with us in the preparation of a new exhibit about electric welding.

"The Fels Planetarium had a useful year—bringing a knowledge and understanding of the stars to hundreds of thousands of school children and adults. This year marks its 20th Anniversary. All in all, our Museum and Planetarium have continued to expand their educational services during this past year.

"Now, let me tell you about our Research and Development Laboratories. Research to help industry has been an activity of the Institute for 120 years. Since we met last year at this time, there has been a good deal accomplished. The Laboratories have become more widely known and are now being called the 'Research Center for Delaware Valley, U.S.A.' National preparedness work has needed about the same amount

of effort. Perhaps our most widely known accomplishment in that field is the so-called Atomic Cannon. But our industrial work has steadily increased, resulting in the best year so far for the Laboratories. Perhaps you would like to know the names of some of the organizations that use our facilities. New work was started for the American Iron & Steel Institute, the American Petroleum Institute, and the Cast Iron Pipe Research Association. Of course, our National Asphalt Research Center has continued to serve 30 producers and users, and work for the American Association of Railroads and other groups and companies has gone forward. The Projection Magnifier, a reading device for the partially sighted, designed in our laboratories under a grant from the Kellogg Foundation, will be produced for sale by the American Optical Company.

"The housing for the largest A. C. Network Analyzer yet built has been completed on the roof of this building. The next few months will see the Analyzer placed in operation to serve seven electric utility companies in this area. This is one of those huge electronic brains that does six months' calculations needed in electric power distribution in as many days.

"I have touched upon some of our larger projects, but I want to stress our service to smaller clients in helping them improve their products or develop new ones. For this research, for large clients or small, we now have over 270 scientists, engineers and technicians.

"The hard-working members of the Committee on Science and the Arts will see the fruition of their labors this evening. Already they are at work on future medal awards.

"The Library has expanded to an impressive 146,000 volumes, including an excellent thousand-volume rare book collection. (A notable rare book gift was a first edition of 'Euclid's Elements of Geometry,' published in 1482," presented to us by Mr. Boies Penrose.) In a test conducted for a short time this year, it was learned that over 200 companies make regular use of our library.

"The JOURNAL OF THE FRANKLIN INSTITUTE has taken on a new look during this year with a more handsome cover but it still continues to publish scientific papers of high caliber and world-wide technical interest.

"The eleven stated Institute lectures held during the winter-spring season of this year were popular as indicated by the large attendance. Among the distinguished speakers were Dr. Milton Eisenhower, Dr. Harlow Shapley, General Leslie Groves, Dr. Harold Urey, a Nobel Prize winner, and Mr. Benjamin F. Fairless, who gave our annual Edward G. Budd Foundation Lecture and was this year's recipient of our Vermilye Medal.

"The Membership Department reports that our membership has continued to rise. It is over 6800 at present, and it is our hope to reach 7000 by the end of the year.

"From our Personnel Department, we learn that the number of employees is now about 600—557 here and 39 at our Bartol Foundation. The Laboratories are, to a great extent, responsible for this year's increase of 40. Working conditions and employee benefits are being improved steadily. And, we have a new Director of Personnel Relations, Mr. John Christ.

"The Friends of Franklin have continued their generous support by contributing during the past eight months over $23,000 to help defray our operating costs.

"The Endowment Department continues to show progress in acquainting people with the mission and purpose of The Franklin Institute and in attracting additional badly needed support—not only through endowments, but also by gifts for specific uses in our Museum, Planetarium, Library and Laboratories.

"Our Bartol Research Foundation, located in Swarthmore, has placed in operation its new Van de Graaff generator and is presently at work on measurements in nuclear physics. Two expeditions, one to India and the other to the Galapagos Islands, have reported success in the investigation of primary cosmic radiation at high altitudes in those areas.

"So that the name of The Franklin Institute may be known more widely and its work understood more intimately, the Public Relations Department is at present engaged in presenting two radio programs and one television program each week on a scheduled basis on time given us by the stations. *The Institute News*, which all of our members receive, is in its 18th year and has now a total circulation of nearly 10,000 and a readership estimated at over 25,000.

"All in all, my friends, The Franklin Institute has had a useful and encouraging year. We think that our ever-growing number of friends will help us continue our usefulness. As our patron saint Benjamin Franklin said, 'Little strokes fell great oaks.' And we have a lot of work that needs doing."

PRESENTATION OF AWARDS

MR. ROLPH: "Thank you, Dr. Allen. Ladies and gentlemen, Dr. Allen has told you of the affairs of the Institute since last year at this time. This is a custom of the Medal Day ceremonies.

"If you will read through the back issues of the JOURNAL OF THE FRANKLIN INSTITUTE in which the Secretary's report is printed as a part of these proceedings, you will note one thing, I am sure, and that is a constant hewing to a line.

"We are witnessing a great change here in the Delaware Valley—an expansion of industries, of educational facilities and services to the needs of the people. In this expansion, a great amount of building is in evidence—factories, bridges, homes, hospitals and transportation facilities.

"In 1824 a plumb line was dropped, a foundation was placed, and on it, to this day we are erecting a structure known as The Franklin Institute. This edifice was built on a foundation which contained the premise that it was to be for the 'promotion of science and the mechanic arts.' If you will read through the reports of those Secretaries of The Franklin Institute, you will note that we are still building on that true line.

"A Museum was established and flourishes—for it is promoting science and the mechanic arts through the medium of demonstrations and active exhibits. It is bringing education to its many visitors in a visible, tangible way—demonstrating applications of basic scientific theories and laws. Our Museum is an inspiring influence upon the lives of young people who have aptitude for a scientific vocation.

"A Library was established to bring together the printed and written words of men of science. That Library has grown in size and usefulness to the extent that hundreds of companies and thousands of individuals turn to it as the source of the technical information they require.

"Finally, there is the baby of The Franklin Institute—our Laboratories for Research and Development. Conceived in 1830, as a small bit of research for the Federal Government, the laboratories that surround us in this and adjacent buildings, and the Bartol Laboratories in Swarthmore have grown to man size. They have done so because they were established on a foundation laid back in 1824, for they certainly are promoting science and the mechanic arts through skillful research.

"With a true and firm foundation, honestly laid and built of good materials, a structure is certain to endure. The Franklin Institute is surely a living example of that.

"But The Franklin Institute is more than a structure, more than an institution. It is also people. The men and women who work in the Museum, the Planetarium, the Library, and the Laboratories; the more than 6800 members, these scientists whom we would honor; the hundreds of thousands of visitors to our Museum—these also are The Franklin Institute. Through their support, by the work of their hands and minds, by the admissions to the Museum they give us and by their thoughtfulness in providing endowments for the future growth of the Institute—they become a part of this edifice we are building.

"The promotion of science and the mechanic arts is not the exclusive property of The Franklin Institute, however, for there is a greater structure being erected which can be called civilization. Some of the workmen are here tonight. By their labors, they are promoting science and the mechanic arts and in so doing are adding to the sum of human knowledge. Each year we seek to recognize their labors by a presentation of medals. Before greeting each one, let us pause for a moment to recognize and salute the members of the Committee on Science and the Arts of The Franklin Institute. It is they who, through the years, study the records, search out the facts and measure the contributions

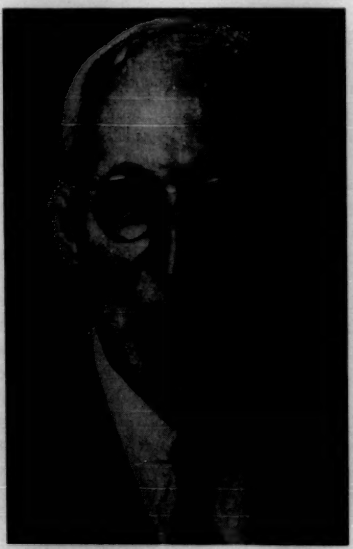
of men to society. As a result of their work, study and recommendations, the awards which we bestow here tonight have become internationally known and respected.

"Each Medalist is sponsored by the Chairman of the Subcommittee of the Committee on Science and the Arts which recommended him for the award. This sponsor will read the citation accompanying each medal."

PRESENTATION OF THE ELLIOTT CRESSON MEDALS

(Founded in 1848)

This medal is awarded for discovery or original research, adding to the sum of human knowledge, irrespective of commercial value; leading and practical utilizations of discovery; and invention, methods or products embodying substantial elements of leadership in their respective classes, or unusual skill or perfection in workmanship.



WILLIAM BLUM

(To William Blum, Electrochemist, Washington, D. C.; George Russell Harrison, Dean, School of Science, Massachusetts Institute of Technology, Cambridge, Massachusetts; and William Frederick Meggers, Spectroscopist, Washington, D. C.)

MR. ROLPH: "First, the Chair recognizes Mr. Alan C. Byers."

MR. BYERS: "Mr. President, I present William Blum for an award.

"Dr. Blum is an electrochemist who has quietly and steadily contributed to the establishment of a rational, scientific understanding of the phenomena involved in the industrial applications of electroplating and electroforming.

"He began his work in this field shortly after he became a member of the staff of the National Bureau of Standards in 1909. Twenty years later, he became Chief of the Electrodeposition Section of that Bureau, in which position he remained until his retirement in 1951.

"His work, reported in more than 100 scientific papers, has emphasized the careful measurements and the controlled experimental conditions which are necessary to allow the development of a precise understanding of the complex reactions which take place in electrodeposition processes. This has led to plated films of greater adhesion and abrasion resistance, of better structure, lower porosity, and greater corrosion resistance.

"By his guidance of his associates, by his work fostering the American Electroplaters Society, and by his cooperation with G. B. Hogaboom in the writing of the standard textbook on the subject, he has furthered the education of a host of electrochemists and stimulated much valuable research.

"For many years, electrodeposition progressed in a halting, haphazard way, as a secret art, a trial-and-error alchemy. Dr. Blum has been a leader in establishing a rational body of knowledge which provides the foundation for sound, scientific progress.

"I present William Blum, of Washington, D. C., as a candidate for an Elliott Cresson Medal, 'In recognition of his long continued and unusually meritorious work in creating a modern scientific basis for the electrodeposition of metals, and for his development of useful processes in that field.' "

MR. ROLPH: "Dr. Blum, by virtue of the power vested in me as President of The Franklin Institute of the State of Pennsylvania, I present to you this Elliott Cresson Medal and the Certificate and Report which accompany it."

DR. BLUM: "Thank you."

MR. ROLPH: "The Chair now recognizes Mr. Joseph Gray Jackson."

MR. JACKSON: "Mr. President, I present George Russell Harrison for an award.

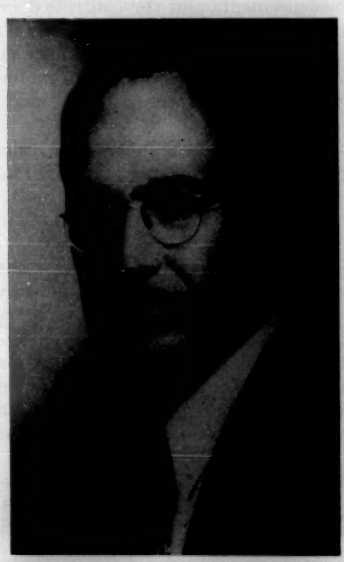
"The atom can be made to broadcast valuable data about itself which are received and recorded by the spectrograph. Then begins the work of solving a crossword puzzle backwards to obtain useful information from the lines on the spectrograph. We have come to rely on Dean Harrison for the equipment to make this game possible and for the massive data such as the M. I. T. Wavelength Tables obtained in this way.

"I present George Russell Harrison, of Cambridge, Massachusetts, as a candidate for an Elliott Cresson Medal, 'For obtaining and refining spectroscopic evidence bearing upon atomic structure, particularly his precision measurements in the Zeeman effect, for his outstanding improvements in the instruments of spectroscopy, and for the invaluable results obtained by these instruments.' "

MR. ROLPH: "By the same authority, Dr. Harrison, I present to you this Elliott Cresson Medal and the Certificate and Report which accompany it."

DR. HARRISON: "Thank you."

MR. ROLPH: "The Chair recognizes Dr. Richard M. Sutton."



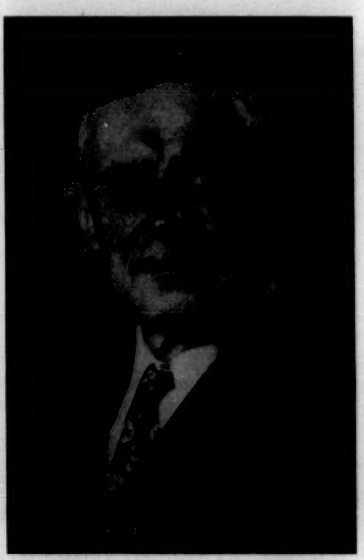
GEORGE RUSSELL HARRISON

DR. SUTTON: "Mr. President, I present William F. Meggers for an award.

"Dr. Meggers is Chief of the Division of Spectroscopy of the National Bureau of Standards. Dr. Meggers' meticulous work during the past forty years has helped to turn the field of spectroscopy into the most precise of all fields of scientific measurement. His accurate evaluation of hundreds of thousands of lines in the spectra of scores of elements has helped to create the solid observational foundation upon which

our modern theories of atomic structure rest. With patience and insight, he has pursued the difficult task of unravelling complicated spectra. His work is of great importance to astronomers, metallurgists, chemists and physicists; and it stands as an example of scientific endeavor of the highest responsibility and integrity. Fortunately, it has been sufficiently far removed from 'the play of the market place' so that it has not yet been made the object of political attack.

"I present William F. Meggers, of Washington, D. C., as a candidate for an Elliott Cresson Medal. 'For his monumental work throughout



WILLIAM FREDERICK MEGGERS

four decades in the field of Spectroscopy,—work which has exhibited a high degree of diligence, consistent accuracy and scientific responsibility, work which has produced much of the reliable experimental data upon which rests our present detailed knowledge of the electronic structure of scores of elements.' "

MR. ROLPH: "Dr. Meggers, by the same authority, I present to you this Elliott Cresson Medal and the Certificate and Report which accompany it."

DR. MEGGERS: "Thank you."

PRESENTATION OF THE EDWARD LONGSTRETH MEDAL

(Founded in 1890)

This Medal is awarded for inventions of high order and for particularly meritorious improvements and developments in machines and mechanical processes.

(To Chester F. Carlson, Patent Attorney and Physicist, Fairport, New York.)

CHESTER F. CARLSON

MR. ROLPH: "The Chair now recognizes Dr. William G. Schmidt."

DR. SCHMIDT: "Mr. President, I present Chester F. Carlson for an award.

"Mr. Carlson is the inventor of a truly remarkable method of copying and reproducing manuscript materials, a method that is quick and flexible and one that has already proved its usefulness in modern business.

"Our own Benjamin Franklin would smile still more quizzically if he were to see this imaginative and practical application of certain old ideas in electricity. For Mr. Carlson's system of Xerography makes use of static electricity and the photoconductivity of selenium to capture a powdery image of the material to be copied. After this image is 'fixed'

by heating briefly, it may be used immediately, even on a Duplimat Master on a Multilith machine in the ordinary way. The process is unique in that it produces a positive immediately and not a negative; and it is a completely dry process as implied in its name, Xerography.

"I present Chester F. Carlson, of Fairport, New York, as a candidate for an Edward Longstreth Medal, 'For his effective combination of known principles of optics, photoconductivity and electrostatics into a workable process for producing facsimiles of written matter, drawings and other documents by a system that is rapid, dry, permanent and also capable of placing a reproducible image on an offset paper master.' "

MR. ROLPH: "Mr. Carlson, by the same authority, I present to you this Edward Longstreth Medal and the Certificate and Report which accompany it."

MR. CARLSON: "Thank you."

MR. ROLPH: "The communication of ideas by the printed word is of such importance that our economy could not exist without it. If you observed the display of equipment in the exhibit room upstairs, you were assured of the feasibility and commercial value of Mr. Carlson's system."

PRESENTATION OF THE LOUIS E. LEVY MEDAL

(Founded in 1923)

This Medal is awarded to the author of a paper of especial merit, published in the JOURNAL OF THE FRANKLIN INSTITUTE, preference being given to one describing the author's experimental and theoretical researches in a subject of fundamental importance.

(To George Cheney Newton, Jr., Associate Director, Servomechanisms Laboratory, Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts.)

MR. ROLPH: "The Chair recognizes Dr. Joseph S. Hepburn."

DR. HEPBURN: "Mr. President, I present George Cheney Newton, Jr., for an award.

"His paper, 'Compensation of Feedback-Control Systems Subject to Saturation,' based on his own researches, is outstanding and of especial merit, and was published in the JOURNAL OF THE FRANKLIN INSTITUTE.

"Much of the technological advance of recent years is due to the increasing use of automatic control devices, and to the increasing precision with which we may control the application of driving forces which work for us. Many of these controls are characterized by their use of 'feedback,' that is, the error, or deviation of the actual output from the

desired output, is used as the control signal which is fed back to the input of the system to cause it to operate.

"The analysis of such control systems, and their design, may proceed in a straightforward way if it is assumed that all parts of the system are well behaved, so that their characteristics can be described in simple mathematical terms. But this is not often the case in practice, and approximations must be made, sometimes with doubtful accuracy. Dr. Newton has presented in his paper a method of analysis which allows

GEORGE CHENEY NEWTON, JR.

a more accurate estimate of system performance than was hitherto possible, in the case when some components are subject to saturation.

"I present George Cheney Newton, Jr., of Cambridge, Massachusetts, as a candidate for the Louis E. Levy Medal, 'In recognition of his outstanding paper, "Compensation of Feedback-Control Systems Subject to Saturation," appearing in the October and November, 1952, issues of the JOURNAL OF THE FRANKLIN INSTITUTE.' "

MR. ROLPH: "Dr. Newton, by the same authority, I present to you this Louis E. Levy Medal and the Certificate and Report which accompany it."

DR. NEWTON: "Thank you."

PRESENTATION OF THE GEORGE R. HENDERSON MEDAL

(Founded in 1924)

This Medal is awarded for meritorious inventions or discoveries in the field of Railway Engineering.

(To Adolph Meyer, Mechanical and Electrical Engineer, Küsnacht-Zürich, Switzerland.)

ADOLPH MEYER

MR. ROLPH: "The Chair recognizes Dr. Rupen Eksergian."

DR. EKSERGIAN: "Mr. President, I present Adolph Meyer for an award.

"The combustion gas turbine works on a differential principle, the turbine output being partly used for driving the compressor, so that the net power resulting from the combustion of the fuel in the combustion chamber is dependent on the efficiencies of both compressor and turbine. Beyond maintaining high flow efficiencies, the over-all output and efficiency are markedly increased through a high entrance temperature to the turbine. Progress on the gas turbine, as a possible competitive power unit, was reflected in a basic development of an axial compressor of high efficiency driven by an exhaust gas turbine, in connection with

the Velox boiler. The Velox steam boiler, with the gas turbine compressor unit for circulating the combustion gases under pressure, was in itself a successful steam power unit. But more important, the combustion gas turbine part of this development proved the engineering and economical possibilities of a separate independent gas turbine power plant. Another parallel development, in the Houdry oil cracking process, also stimulated its use as an independent power unit. Dr. Meyer was mainly responsible for these developments. In 1941, the first continuous constant pressure gas turbine locomotive, developed by Dr. Meyer, was delivered by Brown Boveri Company to the Swiss Federal Railways. It had an output rating at 2200 h.p. A later, and first commercial product, following the same design, was delivered to the Great Western Railway in England in 1950. Dr. Meyer can be regarded as the pioneer in the development of the Gas Turbine Locomotive. Even more important are his fundamental contributions to gas turbine design, and research in this and allied fields.

"I present Adolph Meyer, of Zürich, Switzerland, as a candidate for the George R. Henderson Medal, 'In consideration of his basic contributions to scientific research on the gas turbine power plant and, in particular, to his pioneer work in the development of the first successful Gas Turbine Locomotive.' "

MR. ROLPH: "Dr. Meyer, by the same authority, I present to you this George R. Henderson Medal and the Certificate and Report which accompany it."

DR. MEYER: "Thank you."

PRESENTATION OF THE JOHN PRICE WETHERILL MEDALS

(Founded in 1925)

This Medal is awarded for discovery or invention in the physical sciences or for new and important combinations of principles or methods already known.

(To Robert H. Dalton, and S. Donald Stookey, Research Chemists, Corning Glass Works, Corning, New York.)

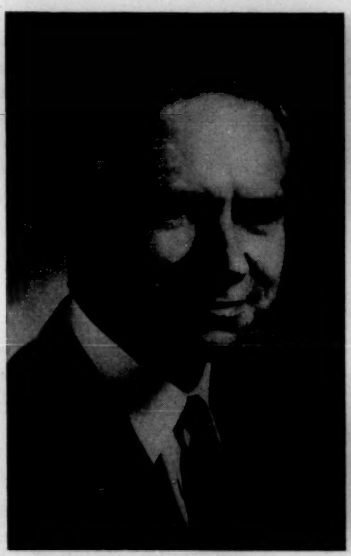
MR. ROLPH: "The Chair now recognizes Mr. Ralph H. McClarren."

MR. MCCLARREN: "Mr. President, I present Robert H. Dalton and S. Donald Stookey for awards.

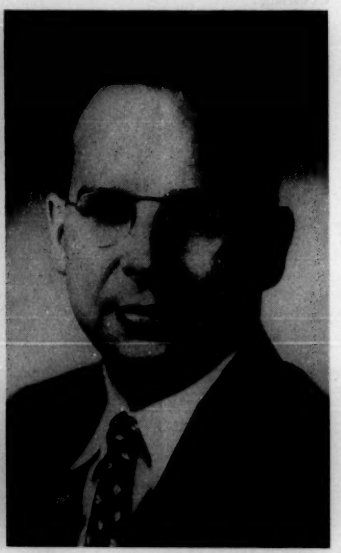
"These research scientists at the Corning Glass Works were concurrently responsible for developing a process entitled 'Photographs in Glass.' Robert H. Dalton undertook initial and basic work wherein light-sensitive ingredients were mixed with glass and formed as an integral part of the finished glass plate. When this glass is exposed to ultra-violet light through a photographic negative, a reaction takes place within the glass. Then when the glass is subjected to a heating process, the reaction started by the ultra-violet light is intensely accel-

erated and an image is formed, in the reverse of the photographic negative, similar to making a photographic print.

"Dr. Stookey perfected the process wherein excellent photographic reproductions were possible and in various colors such as dark blue, purple and red. He also developed the process to make opaque designs in the glass. Such glass is used for industrial lighting purposes and for ornamental uses. An added development is chemical etching, to produce a wide variety of designs and sculpturing effect.



ROBERT H. DALTON



S. DONALD STOOKEY

"I present Robert H. Dalton and S. Donald Stookey, both of Corning, New York, as candidates for John Price Wetherill Medals, 'In consideration of their work in leading to and developing a practical and commercially acceptable method for producing photographs in glass and opalescent designs in glass by photosensitive processes.' "

MR. ROLPH: "By the same authority, I present to each of you these John Price Wetherill Medals and the Certificates and Reports which accompany them."

DR. DALTON: "Thank you."

DR. STOOKEY: "Thank you."

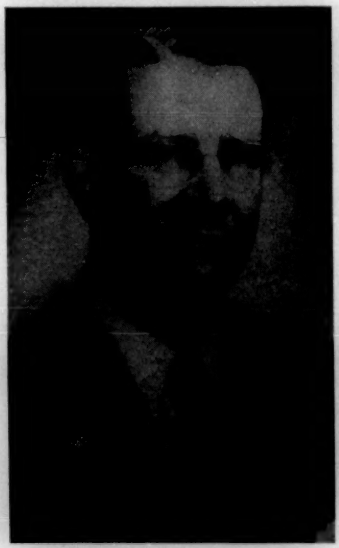
PRESENTATION OF THE FRANK P. BROWN MEDAL

(Founded in 1938)

This Medal is awarded to inventors for discoveries and inventions involving meritorious improvements in the building and allied industries.

(To Frank Lloyd Wright, Architect, Spring Green, Wisconsin.)

The President announced that this award would not be made this evening.



ROBERT FRANKLIN MEHL

PRESENTATION OF THE FRANCIS J. CLAMER MEDAL

(Founded 1943)

This Medal is awarded at least once in five years for meritorious achievement in the field of Metallurgy.

(To Robert Franklin Mehl, Dean of Graduate Studies; Director, Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pennsylvania.)

MR. ROLPH: "The Chair recognizes Dr. G. H. Clamer."

DR. CLAMER: "Mr. President, I present Robert Franklin Mehl for an award.

"Progress in the applications of metals calls for two things: a stock of fundamental knowledge and a body of educated men to make use of that knowledge. When we cease to add to our stock of knowledge and to educate our young men to make use of it, progress stagnates.

"Dr. Mehl is one of those men who recognize the gaps in our fundamental information concerning the behavior of metals and proceed to fill them. While training young men in this important work of advancing the frontiers of knowledge, he has impressed upon them the usefulness of fundamental scientific data in improving the mechanical properties of metals and alloys.

"I present Robert Franklin Mehl, of Pittsburgh, Pennsylvania, as a candidate for the Francis J. Clamer Medal, 'In recognition of his numerous useful contributions in the fields of theoretical and applied metallography and metallurgy.' "

MR. ROLPH: "Dr. Mehl, by the same authority, I present to you this Francis J. Clamer Medal and the Certificate and Report which accompany it."

DR. MEHL: "Thank you."

PRESENTATION OF THE STUART BALLANTINE MEDAL

(Founded in 1946)

This Medal is to be awarded in recognition of outstanding achievement in the fields of Communication and Reconnaissance which employ electromagnetic radiation.

(To David G. C. Luck, Member of the Technical Staff, David Sarnoff Research Center, Radio Corporation of America, Princeton, New Jersey.)

MR. ROLPH: "In July of this year, we lost one of our greatly esteemed and faithful members—Dr. Winthrop R. Wright who was Chairman of the Ballantine Medal Sub-Committee. Tonight the Chair recognizes Mr. Edward L. Forstall, a member of that Committee."

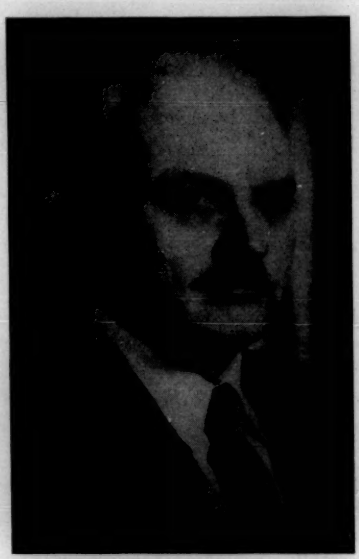
MR. FORSTALL: "Mr. President, I present David G. C. Luck for an award.

"An aeronautical chart was a 'must' from the first days of flying, for, to inquire one's location while in the air was impractical as Lindbergh found out on his flight to Paris. But something more was needed for flying at night or above the clouds. The answer was the radio range, a radio beam which the pilot follows.

"The range system as used for the past twenty years has a number of drawbacks. The pilot may become confused and follow the companion beam which is approximately at right angles or he may follow the correct beam in the wrong direction. Continuous listening to the

beam signal is very monotonous. Finally, the beam is narrow and is available only along established airways.

"Our Medalist has made the next big improvement with his invention of the Omni-Range which sends a beam out in all directions. To approach his destination from any direction, the pilot turns the selector until the needle centers and then flys so it stays that way. A visual indicator says "TO" or "FROM"—he can not unknowingly fly in the wrong direction. Finally, the beam may be hooked to an automatic pilot and take over the whole job—truly an all-weather system of air navigation.



DAVID LUCK

"I present David G. C. Luck, of Princeton, New Jersey, as a candidate for the Stuart Ballantine Medal, 'For his invention of the Omni-directional Radio Range, an essential element in present day air traffic control.' "

MR. ROLPH: "Dr. Luck, on behalf of The Franklin Institute of the State of Pennsylvania, I present to you this Stuart Ballantine Medal and the Certificate and Report which accompany it."

DR. LUCK: "Thank you."

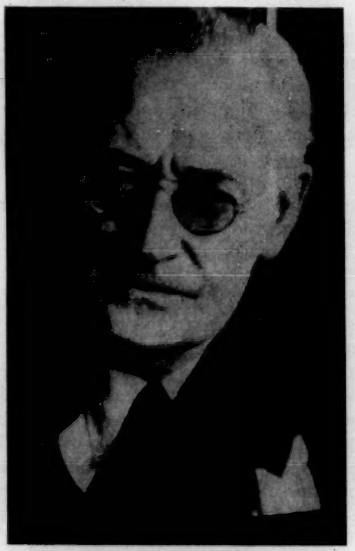
PRESENTATION OF THE FRANKLIN MEDAL

(Founded in 1914)

This Medal is awarded annually to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Institute, acting through its Committee on Science and the Arts, have done most to advance a knowledge of physical science or its applications.

(To William Francis Gibbs, Naval Architect and Marine Engineer, New York, New York.)

Mr. Charles H. Masland, 2nd, Chairman of the Standing Sub-Committee, was unable to act as Sponsor this evening, because of indisposition.



WILLIAM FRANCIS GIBBS

MR. ROLPH: "The Chair recognizes Dr. James Barnes."

DR. BARNES: "Mr. President, I present William Francis Gibbs for an award.

"Mr. Gibbs has a background of education, business experience and service to his country which is equalled by few.

"He was born in Philadelphia and attended the Delancy School. In 1913, Mr. Gibbs and his brother worked, in his father's home in Haverford, on plans for a 1000-foot transatlantic liner. Little more

than a year ago the steamship *United States* was the fulfillment of this early dream.

"He is a graduate of Harvard and Columbia and recently received the honorary degree of Doctor of Science from Harvard University. Needless to say, he has been given many distinguished honors including membership in our National Academy of Sciences.

"In between his early dream and the fulfillment thereof, Mr. Gibbs has done many things. He has striven continuously for safety at sea and has made notable contributions in this field.

"He has adapted for use on shipboard the best ideas in boiler practice, in turbine practice and in pump practice.

"Due to the excellence of his ship designs and the use of standardized products he made it possible to build ships in large numbers on a mass production basis. This was of tremendous value to this country and to our allies during the last world war.

"Mr. President, I present William Francis Gibbs as a candidate for the Franklin Medal, 'Because he has labored successfully for forty years to bring the best of engineering and architecture into shipbuilding, culminating in the construction of the record-breaking *S. S. United States*.' "

MR. ROLPH: "By the authority vested in me as President of The Franklin Institute of the State of Pennsylvania, I present to you this Franklin Medal with its accompanying Certificate, Report, and a Certificate of Honorary Membership in The Franklin Institute."

MR. GIBBS: "Thank you."

MR. ROLPH: "Ladies and gentlemen, these are happy occasions, for we meet here to pay token tribute to the great men of our times. Most of us, embroiled in our daily tasks, give little thought to the speed with which we are progressing in science and technology. When we do notice the improvements in our comfort, our health and our surroundings, we usually see only the finished product—the picture and sound box in the living room, the ease of driving a practically automatic car, the clean lined giant resting easily beside a dock. It is only on occasions such as this that perhaps we look beyond these modern miracles—to the men of vision, the men who brought together the knowledge of the past to do such great work. It is with great pleasure that I present to you, Mr. William Francis Gibbs."

MR. GIBBS: "Thank you, Mr. Rolph."

ADDRESS BY WILLIAM FRANCIS GIBBS

See following page of this JOURNAL for the text of Mr. Gibbs' address.

* * *

After Mr. Gibbs had delivered his talk, Mr. Rolph conveyed to him the thanks of the Institute, dismissed the assembly with a cordial word and declared the meeting adjourned.

THE "SS UNITED STATES"*

BY

WILLIAM FRANCIS GIBBS[1]

I am moved tonight with a feeling of considerable emotion. To stand before this impressive gathering in this Institute that has no peer in the United States and bears the name of one of the most illustrious fathers of our country would give a brilliant person or people such as you have heard eulogized this evening a task to talk to you.

I am laboring under considerable difficulty tonight—beyond that which normally accompanies my feeble effort to talk in public—because when Dr. Allen suggested that it was customary for a Franklin Medalist to make requital in small part for the Medal by talking to this most illustrious audience, I was abashed, as you can well believe. And Dr. Allen pointed out to me in what became rather a voluminous correspondence, that the time of my address was first to be fifteen minutes, and then, on further thought and feeling for all of you, he suggested that it would be ten minutes. While I sat at the table tonight your illustrious President pointed out that they had every hope, and his great effort would be, to keep this subject on time tonight, and he looked furtively at his watch and pointed out that we were behind.

I said, "How long do you think I should talk?" He replied, "Do you think you need more than ten minutes?" I thought I detected a note of sadness in his voice. I said "It may be. I can only suggest a time beyond ten minutes when I face this illustrious audience and see the state that they are in after this hard evening of heavy eating and of these marvelous presentations"—presentations that I have heard made tonight for work done which, to my poor understanding, seems simply incredible. And then, to make the whole situation more serious to me, I am put last on the program and I face you all with a feeling that at least two-thirds of all the people in this room are commuters and that you inevitably have your eye on the 10:15 train and, furthermore, that you are completely tired out.

Notwithstanding all of these discouragements to an address, I told Mr. Rolph my test would be when I looked over this audience and saw numerous of them sleeping peacefully. I told him it would not disturb me in the slightest degree until they began to snore audibly. I haven't heard anybody snoring yet, but that is your privilege and when a majority of the audience snores I will come to a conclusion.

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* Delivered at the 1953 Medal Day Meeting, October 21, 1953, in acceptance of the Franklin Medal.

[1] Gibbs & Cox, Inc., New York, N. Y.

I don't believe that you know what I have written on this bit of paper that I hold up. These are all the things that I mustn't say.

I have a brother who is here present. We have been associated ever since we went to work. Everything that I have done he has provided the sinews of war for. I think the most important, or one of the most important, things to me is that he pays my salary. But seriously, he has contributed a good deal more than half of everything that I have done in the world and received credit for. But he is a modest man and he stays in the background, and he gives me extraordinarily good advice. When he heard I was coming over here and I was to make this address, he gave me a very good piece of advice. He said "Say nothing." And I can tell from the blithe look on your faces that you completely agree with him.

I think it is fair to say that my remarks thus far are completely out of keeping with our surroundings. Certainly this galaxy of brilliant minds at my back and this brilliant audience before me would make me feel diffident. May I digress just one moment more? I have been impressed with the superb arrangements of this meeting, for I have never seen a meeting of this kind better conducted. I was amazed when I sat at dinner, looking out over the youth and beauty of this audience, to know how it was possible to gather together a group of this kind in the evening with all the blandishments with which evenings in Philadelphia are surrounded. When I sat down here and looked up at you and heard the Medalists introduced, I realized that *there* was the secret of your method. You see, even in my limited mathematical capacity, I realized that if The Franklin Institute gives enough medals every year and they invite the Medalists to come here to be applauded, you are bound to have an intelligent audience. I counted when the Medalists stood and I think there are fifteen people in this room who are not Medalists. I mean men, not women. I assume the women are here because they had to come.

I think we can say "have done with levity" because it ill accords with our surroundings or the importance of this occasion.

Mr. President, I accept this Medal not for myself, because in my mind's eye I see hundreds and thousands of people who have contributed to this ship that you honor me for tonight. If you look at the building of such a ship; if you measure what has to go into it; if you realize the far-reaching extent of such a structure and such an apparatus, you have before your mind's eye literally thousands of people. And the extraordinary thing about this particular endeavor is the fact that American industry, that Government authorities such as the Navy, the Maritime Administration, the Coast Guard, the American Bureau of Shipping and other authorities which I think add up to ten, and the people who actually did the building of the ship and also all those who contributed to the components of this ship—all these people understood what they

were doing. The basic understanding was that for once we were aiming at nothing but perfection.

Perfection, Mr. President, is an extremely hard task-master. Perfection in the arts and sciences does not come easily. It comes hard. To get perfection you have to demand perfection and the people who demand perfection are rarely popular.

Beneath this rough exterior beats a heart of granite, and the only function I performed in connection with this ship was to demand perfection from anybody who had anything to do with it. And when it comes to perfection I believe that I am implacable. There are men sitting in this audience tonight to whom I would not have had the nerve—even though it comes easily to me—to be as disagreeable and demanding as I have been, had I not been concerned with this great project, as a trustee for the citizens of the United States. I could not have been so demanding had I not been clear that these men were responsible for the design and manufacture of the components and the building of the ship and had I not been sure that they understood what this project meant to the citizens of the United States.

This is an evening of deep feeling for me. Even though my heart is of the nature that I have described, it melts at the welcome I have received this evening. In this City I was born. In this City, many years ago, I was taken by my parents to see a great ship launched at the Cramp Yard. That was my first view of a great ship and from that day forward I dedicated my life to ships. I have never regretted it.

You can appreciate what it meant to us—as the result of the sight of that ship—to conceive of the first ship that we ever worked on as a thousand-foot one. Actually, many years ago, we tested in the Model Basin in Washington the first one-thousand foot ship model that was ever run in the world.

Two World Wars intervened and at the close of the Second World War, in which we had done a good deal of work for the Navy, my brother and I sat down with General Franklin on his return to the United States Lines. We discussed the possibility of a great ship, and it was the consensus that such a ship, if it was to be built, should be built primarily for the national defense of the United States and we would try to combine in such a design the requirements of a passenger ship. The result was that General Franklin became enthused and he backed us—with the millions necessary—to force through such a ship so far as the United States Lines was concerned.

But, strange to say, it didn't take much forcing, because when we presented our ideas to the Navy, the Maritime Commission, and Coast Guard, in Washington, they were received with enthusiasm. The result is that in the *United States* you have a naval vessel and a merchant passenger ship of the highest type, combined in one.

And the outstanding thing about that ship is what the Navy calls

the "power of survival," and that power of survival is of interest to every one of you who goes to sea in a ship. It is the power that the ship has of staying afloat and not burning up in case of an accident, collision, or a fire on board. And that, Mr. President, is the difference between the *United States* and all other merchant ships and all other auxiliaries for the Navy.

The ship has an enormous reserve for flotation and is absolutely fireproof—the first time that that has ever been done. The ship is entirely different from any of the ships of the past. It had to be different. You couldn't accomplish these two simultaneously—what had always been regarded as antithetical conceptions—unless the whole method of design were changed. That has been done in the *United States*. Not by me, but by the hundreds of people, my associates, the shipyard, the Government authorities, and the men who built the ship—and, most important, American industry.

Now, it might be that I would be standing before you and telling you what this ship *might* do. Fortunately, I can tell you tonight what it *has* done. The Bible has some very wise sayings, one of which is "By their works ye shall know them" and so, by what the *United States* has done, you may know the nature of the ship and I am going to draw your attention to a very few of those items.

I am sure that you will understand what I am talking about. There will be very little of statistics and there will be very few words of description that you won't understand.

First, the ship has operated for fifteen months and has made in that time the equivalent of eight trips around the world. It has operated during that time at an average speed of better than thirty knots and on only fifteen days of the fifteen months has the weather been so bad that the ship hasn't maintained a daily average of thirty knots—an unprecedented performance.

But the interesting thing is the ship's maiden voyage. It had left Newport News with a superb crew and, after an overnight run to New York, it set sail on July 3, 1952 on the maiden voyage. On that maiden voyage it broke the Atlantic record both east and west bound, as you know. It made an average speed of thirty-five knots, but the interesting thing is that in more than one hundred years of steam navigation on the North Atlantic, the record has been broken more than one hundred times, but the maximum increase in speed in any of those record breaking performances was slightly less than two knots. The *United States* broke the record by four knots, or double the greatest record breaking performance that had been made in the one hundred thirty-eight years of steam navigation.

And lastly, the propeller shafts have never stopped in the fifteen months by reason of a mechanical derangement nor has the ship been a minute late sailing because of any mechanical defect.

Now, all that I have said to you and the fact that I have studied the arts in college, that I have a law degree, that I have a Master of Arts degree, that I am a member of the Bar, and that the naval architectural societies to which we all belong allege that I am a naval architect and an engineer—all this indicates to you that I am a jack of all trades and master of none. My sole contribution in this performance is the fact that I took the responsibility for failure, and when you realize that a great ship like this is the most complicated structure or apparatus that a man puts together, you can see that that is not much of an encomium on my intelligence.

It think it is appropriate that we should draw a generalized lesson from this amazing cooperation of a vast number of people in a common project. And the people who did this job understood what they were doing. They knew that they were trying for the greatest ship in the world and they knew that they were doing it as trustees for the citizens of the United States They were made aware of that by continuous preaching, and I have the feeling that the reason that this was possible in the United States, with all of its checks and balances, all the difficulties of discussion of all kinds by those opposed to ships and those for ships, all of the arguments that could be made as to the type of design, and all the rest of it, I feel that this result coming out of it indicates the strength of a free society and individual initiative. It is a tribute to the American system.

And now I am going to close. You know—Dr. Mutch will tell you—when a preacher preaches he starts with a text. I am not a preacher so I put my text at the end and my text is taken from the Gospel according to St. Luke, the 14th Chapter and the 11th Verse: It reads:

> For whosoever exalteth himself shall be abased and he that humbleth himself shall be exalted.

Humility and belief in divine guidance, in your fellow man, and what they have done for you, and the little part that you can play yourself, are characteristics that all of us can embrace and employ. These characteristics, at the present moment, in my opinion, are needed more by this great nation today than they ever were in the past.

I close with the hope that the effort of all these people who made possible the performance of this ship will be a matter of pleasure and satisfaction to the citizens of the United States whose trustees they were, and I hope that the performance of the *United States* will justify itself to our citizens and will justify this highest award of this distinguished Institute that I am receiving tonight. I thank you from the bottom of my heart for giving it to me, but I receive it only as a trustee for the myriads of people that made it possible.

Tiny Alnico Magnet Does Six Jobs at Once.—An Alnico magnet that performs six distinct jobs simultaneously has been developed for use in an electronic recorder of unusual design. The Alnico V permanent magnet, less than ¼-in. square, is made of nickel, aluminum, cobalt and iron. It gets magnetized in the process of being heat-treated. When attached to the pen arm of the Multi-Record Dynalog Recorder, made by the Foxboro Company, Foxboro, Mass., the tiny Alnico V permanent magnet provides for precise and dependable measurements of temperature, pressure, humidity and other variables all at once.

Its function is to pick off, either at once or in sequence, six differently colored pens so that each pen will be inked by its own pad and no other. It is shaped to hold the pen points in precise position while the dot is penned on the chart. A full day's or week's record of up to six measurements can be completed on one circular chart.

In operation it does the work of six instruments but uses only one chart and one pen arm for recording all of them. An electric signal causes the pen arm magnet to pick up any or all of the six pen points and ink the chart according to the impulses received.

Applications in industry are numerous: In open hearth furnaces, for example, the recorder measures the temperature of the checker chambers. In brewing, the instrument stands guard over the pasteurization process to assure the quality of the bottled brew. In power stations, compressors, generators, pumps and similar machinery are protected from overheating by the instrument. Other uses include brick and ceramic kilns, petroleum refineries, chemical retorts, caustic cookers and reactors, etc., wherever an accurate record of more than one measurement is required.

Poland Receives Priceless Copernicus Manuscript from Czechoslovakia.—Poland has received from Czechoslovakia the original manuscript of the major work of the great Polish astronomer, Nicholas Copernicus. Known in Latin as "De Revolutionibus Orbium Coelestium Libri VI" (Concerning the Revolutions of the Heavenly Spheres), the priceless document which altered man's concept of the universe had been in Czechoslovakia for the last 400 years. The manuscript is now on view in the National Museum in Warsaw.

First to see the manuscript after its return to Poland on September 15, were the participants in the special session held by the Polish Academy of Sciences to commemorate the 410th anniversary of Copernicus' death. (The 400th anniversary could not be observed because Poland was then under occupation by Nazi forces.) The session was one of the major events in tribute to Copernicus that have been taking place in Poland during 1953. Attending the session (September 15–16) were scientists from many parts of the world, several of whom reported that Copernicus commemorations were also being held in their own countries.

The Copernicus manuscript presented to Poland by Czechoslovakia was the property of its first editor, George Joachim Rheticus of Wittenberg University and a great Copernican disciple. After the death of Rheticus in 1576, it came into the possession of one of the latter's disciples, Valentin Othon, professor of mathematics at Heidelberg University, who sold it to the university's dean, Christmann. When the latter died, the manuscript was purchased by Jara Amos Komensky, a great Czechoslovak scientist. From about 1640, the document was kept in the library of the Nostitz counts in Czechoslovakia.

THE MEANING OF THE VECTOR LAPLACIAN

BY

PARRY MOON [1] AND DOMINA EBERLE SPENCER [2]

ABSTRACT

The increasing use of Maxwell's equations necessitates a careful consideration of the best formulation for electromagnetic problems. Advance in the past has been hindered by an unfortunate notation that employs the same symbol ∇^2 for two entirely different operators—the vector Laplacian and the scalar Laplacian. A general equation is developed in this paper for the vector Laplacian in any orthogonal, curvilinear coordinate system; and this equation allows the simple formulation of all electrodynamic problems by means of the vector Helmholtz equation,

$$\bigstar \mathbf{E}^* + \gamma^2 \mathbf{E}^* = 0.$$

1. INTRODUCTION

A decade or two ago, electrical engineers felt that Maxwell's equations were something too erudite to be included in an engineering curriculum. But today, electromagnetic theory is an absolute necessity in the study of radio, radar, waveguides, and antennae. Laplace's equation and the *scalar* wave equation have become familiar to most engineers, but the corresponding *vector* equations are still somewhat unfamiliar.

The scalar Laplacian ∇^2, operating on φ, is written in rectangular coordinates as

$$\nabla^2 \varphi = \frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial y^2} + \frac{\partial^2 \varphi}{\partial z^2}. \tag{1}$$

In circular-cylinder coordinates (r,ψ,z), for example,

$$\nabla^2 \varphi = \frac{\partial^2 \varphi}{\partial r^2} + \frac{1}{r}\frac{\partial \varphi}{\partial r} + \frac{1}{r^2}\frac{\partial^2 \varphi}{\partial \psi^2} + \frac{\partial^2 \varphi}{\partial z^2}. \tag{2}$$

The corresponding expressions for other coordinate systems are well known (1).[3]

It seems natural to expect the components of $\nabla^2 \mathbf{E}$ to have the same form as in the scalar case. In particular, engineers often assume that if $\mathbf{E}$ has only one component, then $\nabla^2 E$ has the same form as $\nabla^2 \varphi$. This is by no means always the case. For instance, in circular-cylinder co-

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[3] The boldface numbers in parentheses refer to the references appended to this paper.

ordinates with **E** independent of ψ and z, the r-component of the vector Laplacian of **E**, $\nabla^2\mathbf{E}$, is

$$\frac{\partial^2 E_r}{\partial r^2} + \frac{1}{r}\frac{\partial E_r}{\partial r} - \frac{1}{r^2}E_r;$$

but the scalar Laplacian of the r-component of **E**, $\nabla^2 E_r$, is

$$\frac{\partial^2 E_r}{\partial r^2} + \frac{1}{r}\frac{\partial E_r}{\partial r}.$$

The extra term will, of course, change the character of the solution.

The difficulty is primarily one of *notation*. The symbol ∇^2 has been used with two widely different meanings: (*a*) As the scalar Laplacian, ∇^2 is a shorthand abbreviation for the divergence of the gradient:

$$\nabla^2\varphi \equiv \text{div grad } \varphi. \tag{3}$$

(*b*) As the vector Laplacian,

$$\nabla^2\mathbf{E} \equiv \text{grad div } \mathbf{E} - \text{curl curl } \mathbf{E}. \tag{4}$$

Thus two entirely different operators are designated by the same symbol. The only possible excuse for this state of affairs is that the two happen to have the same form in rectangular coordinates. In the interest of clarity, however, a new symbol (say ★) is needed for the vector Laplacian.

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2. THE TEXTBOOKS

The difference between the scalar and vector Laplacians is not unrecognized, though many textbooks on vector analysis and electromagnetism are strangely reticent on the subject. In some, the vector Laplacian is ignored completely. In others, the treatment is confined to giving the formal definition. In still others, statements are made that are almost sure to be misinterpreted. In no case have we found a general expression in curvilinear coordinates, such as given in the next section.

According to Gibbs-Wilson (2), "Let **V** be a vector function, and V_1, V_2, V_3 its three components. The operator $\nabla\cdot\nabla$ of Laplace may be applied to **V**. If a vector function **V** satisfies Laplace's equation, each of its components does." The last statement is true only in orthogonal Cartesian coordinates, which is probably what the authors had in mind. But no restriction is stated.

Similarly for Coffin (3): "When ∇^2 is applied to a vector function, it means that it is applied to the three scalar-function components of the vector function, and hence offers no new difficulty. If $\nabla^2\mathbf{F} = 0$, then $\nabla^2 F_1 = 0$, $\nabla^2 F_2 = 0$, $\nabla^2 F_3 = 0$. That is the three components of **F**

satisfy Laplace's equation." A more misleading statement could hardly be imagined.

Wills (4), Lohr (5), and others write

$$\nabla^2\mathbf{V} = \frac{\partial^2\mathbf{V}}{\partial x^2} + \frac{\partial^2\mathbf{V}}{\partial y^2} + \frac{\partial^2\mathbf{V}}{\partial z^2}$$

with no warning that this is valid only in a very special case. Stratton (6) includes such a warning but most of the treatises do not. Some treatments of vector analysis seem to be so wedded to rectangular coordinates that the inherent beauty and generality of the subject are obscured. Statements appearing in vector analysis should have tensor significance—that is, they should be valid *in all coordinate systems.*

3. GENERALIZED COORDINATES

Consider the general curvilinear coordinates (u^1, u^2, u^3). We shall limit ourselves to orthogonal coordinate systems in euclidean 3-space, each system being characterized by the metric coefficients g_{11}, g_{22}, g_{33}. The element of distance is specified (7) by

$$(ds)^2 = g_{11}(du^1)^2 + g_{22}(du^2)^2 + g_{33}(du^3)^2. \tag{5}$$

Also,

$$\text{grad } \varphi = \mathbf{a}_1 \frac{1}{\sqrt{g_{11}}}\frac{\partial\varphi}{\partial u^1} + \mathbf{a}_2 \frac{1}{\sqrt{g_{22}}}\frac{\partial\varphi}{\partial u^2} + \mathbf{a}_3 \frac{1}{\sqrt{g_{33}}}\frac{\partial\varphi}{\partial u^3}, \tag{6}$$

$$\text{div } \mathbf{E} = \frac{1}{\sqrt{g}}\left\{ \frac{\partial}{\partial u^1}\left(\sqrt{\frac{g}{g_{11}}}\,E_1\right) + \frac{\partial}{\partial u^2}\left(\sqrt{\frac{g}{g_{22}}}\,E_2\right) + \frac{\partial}{\partial u^3}\left(\sqrt{\frac{g}{g_{33}}}\,E_3\right)\right\}, \tag{7}$$

and

$$\begin{aligned}\text{curl } \mathbf{E} = {} & \mathbf{a}_1\sqrt{\frac{g_{11}}{g}}\left[\frac{\partial}{\partial u^2}(\sqrt{g_{33}}E_3) - \frac{\partial}{\partial u^3}(\sqrt{g_{22}}E_2)\right] \\ & + \mathbf{a}_2\sqrt{\frac{g_{22}}{g}}\left[\frac{\partial}{\partial u^3}(\sqrt{g_{11}}E_1) - \frac{\partial}{\partial u^1}(\sqrt{g_{33}}E_3)\right] \\ & + \mathbf{a}_3\sqrt{\frac{g_{33}}{g}}\left[\frac{\partial}{\partial u^1}(\sqrt{g_{22}}E_2) - \frac{\partial}{\partial u^2}(\sqrt{g_{11}}E_1)\right],\end{aligned} \tag{8}$$

where $\mathbf{a}_i$ are unit vectors and $g = g_{11}g_{22}g_{33}$.

Substituting Eqs. 6, 7, and 8 in 4, we obtain (8) the general expression for the vector Laplacian, operating on $\mathbf{E}$:

$$\star\,\mathbf{E} = \mathbf{a}_1\Big\{\frac{1}{\sqrt{g_{11}}}\frac{\partial}{\partial u^1}\Big[\frac{1}{\sqrt{g}}\frac{\partial}{\partial u^1}\Big(\sqrt{\frac{g}{g_{11}}}\,E_1\Big)\Big] + \frac{1}{\sqrt{g_{11}}}\frac{\partial}{\partial u^1}\Big[\frac{1}{\sqrt{g}}$$
$$\frac{\partial}{\partial u^2}\Big(\sqrt{\frac{g}{g_{22}}}\,E_2\Big)\Big] + \frac{1}{\sqrt{g_{11}}}\frac{\partial}{\partial u^1}\Big[\frac{1}{\sqrt{g}}\frac{\partial}{\partial u^3}\Big(\sqrt{\frac{g}{g_{33}}}\,E_3\Big)\Big] - \sqrt{\frac{g_{11}}{g}}$$
$$\times\frac{\partial}{\partial u^2}\Big[\frac{g_{33}}{\sqrt{g}}\frac{\partial}{\partial u^1}(\sqrt{g_{22}}E_2)\Big] + \sqrt{\frac{g_{11}}{g}}\frac{\partial}{\partial u^2}\Big[\frac{g_{33}}{\sqrt{g}}\frac{\partial}{\partial u^2}(\sqrt{g_{11}}E_1)\Big]$$
$$+\sqrt{\frac{g_{11}}{g}}\frac{\partial}{\partial u^3}\Big[\frac{g_{22}}{\sqrt{g}}\frac{\partial}{\partial u^3}(\sqrt{g_{11}}E_1)\Big]$$
$$-\sqrt{\frac{g_{11}}{g}}\frac{\partial}{\partial u^3}\Big[\frac{g_{22}}{\sqrt{g}}\frac{\partial}{\partial u^1}(\sqrt{g_{33}}E_3)\Big]\Big\}$$
$$+\mathbf{a}_2\Big\{\frac{1}{\sqrt{g_{22}}}\frac{\partial}{\partial u^2}\Big[\frac{1}{\sqrt{g}}\frac{\partial}{\partial u^2}\Big(\sqrt{\frac{g}{g_{22}}}\,E_2\Big)\Big] + \frac{1}{\sqrt{g_{22}}}\frac{\partial}{\partial u^2}\Big[\frac{1}{\sqrt{g}}$$
$$\frac{\partial}{\partial u^3}\Big(\sqrt{\frac{g}{g_{33}}}\,E_3\Big)\Big] + \frac{1}{\sqrt{g_{22}}}\frac{\partial}{\partial u^2}\Big[\frac{1}{\sqrt{g}}\frac{\partial}{\partial u^1}\Big(\sqrt{\frac{g}{g_{11}}}\,E_1\Big)\Big] - \sqrt{\frac{g_{22}}{g}}$$
$$\times\frac{\partial}{\partial u^3}\Big[\frac{g_{11}}{\sqrt{g}}\frac{\partial}{\partial u^2}(\sqrt{g_{33}}E_3)\Big] + \sqrt{\frac{g_{22}}{g}}\frac{\partial}{\partial u^3}\Big[\frac{g_{11}}{\sqrt{g}}\frac{\partial}{\partial u^3}(\sqrt{g_{22}}E_2)\Big]$$
$$+\sqrt{\frac{g_{22}}{g}}\frac{\partial}{\partial u^1}\Big[\frac{g_{33}}{\sqrt{g}}\frac{\partial}{\partial u^1}(\sqrt{g_{22}}E_2)\Big]$$
$$-\sqrt{\frac{g_{22}}{g}}\frac{\partial}{\partial u^1}\Big[\frac{g_{33}}{\sqrt{g}}\frac{\partial}{\partial u^2}(\sqrt{g_{11}}E_1)\Big]\Big\}$$
$$+\mathbf{a}_3\Big\{\frac{1}{\sqrt{g_{33}}}\frac{\partial}{\partial u^3}\Big[\frac{1}{\sqrt{g}}\frac{\partial}{\partial u^3}\Big(\sqrt{\frac{g}{g_{33}}}\,E_3\Big)\Big] + \frac{1}{\sqrt{g_{33}}}\frac{\partial}{\partial u^3}\Big[\frac{1}{\sqrt{g}}$$
$$\frac{\partial}{\partial u^1}\Big(\sqrt{\frac{g}{g_{11}}}\,E_1\Big)\Big] + \frac{1}{\sqrt{g_{33}}}\frac{\partial}{\partial u^3}\Big[\frac{1}{\sqrt{g}}\frac{\partial}{\partial u^2}\Big(\sqrt{\frac{g}{g_{22}}}\,E_2\Big)\Big] - \sqrt{\frac{g_{33}}{g}}$$
$$\times\frac{\partial}{\partial u^1}\Big[\frac{g_{22}}{\sqrt{g}}\frac{\partial}{\partial u^3}(\sqrt{g_{11}}E_1)\Big] + \sqrt{\frac{g_{33}}{g}}\frac{\partial}{\partial u^1}\Big[\frac{g_{22}}{\sqrt{g}}\frac{\partial}{\partial u^1}(\sqrt{g_{33}}E_3)\Big]$$
$$+\sqrt{\frac{g_{33}}{g}}\frac{\partial}{\partial u^2}\Big[\frac{g_{11}}{\sqrt{g}}\frac{\partial}{\partial u^2}(\sqrt{g_{33}}E_3)\Big]$$
$$-\sqrt{\frac{g_{33}}{g}}\frac{\partial}{\partial u^2}\Big[\frac{g_{11}}{\sqrt{g}}\frac{\partial}{\partial u^3}(\sqrt{g_{22}}E_2)\Big]\Big\}. \quad (9)$$

This is much more complex than the scalar case:

$$\nabla^2\varphi = \frac{1}{\sqrt{g}}\Big[\frac{\partial}{\partial u^1}\Big(\frac{\sqrt{g}}{g_{11}}\frac{\partial\varphi}{\partial u^1}\Big) + \frac{\partial}{\partial u^2}\Big(\frac{\sqrt{g}}{g_{22}}\frac{\partial\varphi}{\partial u^2}\Big) + \frac{\partial}{\partial u^3}\Big(\frac{\sqrt{g}}{g_{33}}\frac{\partial\varphi}{\partial u^3}\Big)\Big]. \quad (10)$$

In *rectangular coordinates*, $g_{11} = g_{22} = g_{33} = 1$, and

$$\begin{aligned} \bigstar \mathbf{E} = \mathbf{a}_x &\left[\frac{\partial^2 E_x}{\partial x^2} + \frac{\partial^2 E_x}{\partial y^2} + \frac{\partial^2 E_x}{\partial z^2} \right] \\ + \mathbf{a}_y &\left[\frac{\partial^2 E_y}{\partial x^2} + \frac{\partial^2 E_y}{\partial y^2} + \frac{\partial^2 E_y}{\partial z^2} \right] \\ + \mathbf{a}_z &\left[\frac{\partial^2 E_z}{\partial x^2} + \frac{\partial^2 E_z}{\partial y^2} + \frac{\partial^2 E_z}{\partial z^2} \right] \end{aligned} \tag{9a}$$

while

$$\nabla^2 \varphi = \frac{\partial^2 \varphi}{\partial x^2} + \frac{\partial^2 \varphi}{\partial y^2} + \frac{\partial^2 \varphi}{\partial z^2}. \tag{10a}$$

In this special case, each component of $\bigstar \mathbf{E}$ has the same form as $\nabla^2 \varphi$.

In *circular-cylinder coordinates* (r,ψ,z), $g_{11} = 1$, $g_{22} = r^2$, $g_{33} = 1$. Thus, for Eqs. 9 and 10,

$$\begin{aligned} \bigstar \mathbf{E} = \mathbf{a}_r &\left[\frac{\partial^2 E_r}{\partial r^2} + \frac{1}{r}\frac{\partial E_r}{\partial r} - \frac{E_r}{r^2} + \frac{1}{r^2}\frac{\partial^2 E_r}{\partial \psi^2} - \frac{2}{r^2}\frac{\partial E_\psi}{\partial \psi} + \frac{\partial^2 E_r}{\partial z^2} \right] \\ + \mathbf{a}_\psi &\left[\frac{\partial^2 E_\psi}{\partial r^2} + \frac{1}{r}\frac{\partial E_\psi}{\partial r} - \frac{E_\psi}{r^2} + \frac{1}{r^2}\frac{\partial^2 E_\psi}{\partial \psi^2} + \frac{2}{r^2}\frac{\partial E_r}{\partial \psi} + \frac{\partial^2 E_\psi}{\partial z^2} \right] \\ + \mathbf{a}_z &\left[\frac{\partial^2 E_z}{\partial r^2} + \frac{1}{r}\frac{\partial E_z}{\partial r} + \frac{1}{r^2}\frac{\partial^2 E_z}{\partial \psi^2} + \frac{\partial^2 E_z}{\partial z^2} \right] \end{aligned} \tag{9b}$$

and

$$\nabla^2 \varphi = \frac{\partial^2 \varphi}{\partial r^2} + \frac{1}{r}\frac{\partial \varphi}{\partial r} + \frac{1}{r^2}\frac{\partial^2 \varphi}{\partial \psi^2} + \frac{\partial^2 \varphi}{\partial z^2}. \tag{10b}$$

The first two components of $\bigstar \mathbf{E}$ are of different form from $\nabla^2 \varphi$, each containing two additional terms.

In *spherical coordinates* (r,θ,ψ), $g_{11} = 1$, $g_{22} = r^2$, $g_{33} = r^2 \sin^2\theta$, and Eqs. 9 and 10 become

$$\begin{aligned} \bigstar \mathbf{E} = \mathbf{a}_r &\left[\frac{\partial^2 E_r}{\partial r^2} + \frac{2}{r}\frac{\partial E_r}{\partial r} - \frac{2\,E_r}{r^2} + \frac{1}{r^2}\frac{\partial^2 E_r}{\partial \theta^2} + \frac{\cot\theta}{r^2}\frac{\partial E_r}{\partial \theta} \right. \\ &\left. + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 E_r}{\partial \psi^2} - \frac{2}{r^2}\frac{\partial E_\theta}{\partial \theta} - \frac{2\cot\theta}{r^2} E_\theta - \frac{2}{r^2 \sin\theta}\frac{\partial E_\psi}{\partial \psi} \right] \\ + \mathbf{a}_\theta &\left[\frac{\partial^2 E_\theta}{\partial r^2} + \frac{2}{r}\frac{\partial E_\theta}{\partial r} - \frac{1}{r^2 \sin^2\theta} E_\theta + \frac{1}{r^2}\frac{\partial^2 E_\theta}{\partial \theta^2} + \frac{\cot\theta}{r^2}\frac{\partial E_\theta}{\partial r} \right. \end{aligned}$$

(*continued on next page*)

$$+\frac{1}{r^2\sin^2\theta}\frac{\partial^2 E_\theta}{\partial\psi^2}+\frac{2}{r^2}\frac{\partial E_r}{\partial\theta}-\frac{2\cot\theta}{r^2\sin\theta}\frac{\partial E_\psi}{\partial\psi}\Big]$$

$$+\mathbf{a}_\psi\Big[\frac{\partial^2 E_\psi}{\partial r^2}+\frac{2}{r}\frac{\partial E_\psi}{\partial r}-\frac{1}{r^2\sin^2\theta}E_\psi+\frac{1}{r^2}\frac{\partial^2 E_\psi}{\partial\theta^2}+\frac{\cot\theta}{r^2}\frac{\partial E_\psi}{\partial\theta}$$

$$+\frac{1}{r^2\sin^2\theta}\frac{\partial^2 E_\psi}{\partial\psi^2}+\frac{2}{r^2\sin\theta}\frac{\partial E_r}{\partial\psi}+\frac{2\cot\theta}{r^2\sin\theta}\frac{\partial E_\theta}{\partial\psi}\Big] \quad (9c)$$

and

$$\nabla^2\varphi=\frac{\partial^2\varphi}{\partial r^2}+\frac{2}{r}\frac{\partial\varphi}{\partial r}+\frac{1}{r^2}\frac{\partial^2\varphi}{\partial\theta^2}+\frac{\cot\theta}{r^2}\frac{\partial\varphi}{\partial\theta}+\frac{1}{r^2\sin^2\theta}\frac{\partial^2\varphi}{\partial\psi^2}. \quad (10c)$$

Here each component of $\bigstar\,\mathbf{E}$ contains more terms than $\nabla^2\varphi$. Other coordinates are handled in the same manner as the foregoing three cases. In the more complicated coordinate systems, the difference between the vector and scalar Laplacians becomes even more pronounced.

EXAMPLES

As examples of the use of the vector Laplacian, consider two simple cases which are familiar to electrical engineers: skin effect in a wire, and induction heating of a rod of circular cross section. Both cases are usually handled by the rather complicated process of taking a current filament and determining its inductance and impedance. It is simpler, however, to treat the problem by means of Maxwell's equations, obtaining the *vector Helmholtz equation:*

$$\bigstar\,\mathbf{J}^*-i\omega\mu\sigma\mathbf{J}^*=0, \quad (11)$$

with current density $\mathbf{J}=\mathbf{J}^*(u^1,u^2,u^3)e^{i\omega t}$, the starred quantities being, in general, complex.

Consider a long, straight, cylindrical conductor of radius a, at sufficient distance from other conductors so that proximity effect is negligible. The J-vector is in the z-direction; and because of symmetry,

$$\frac{\partial J_z^*}{\partial\psi}=0, \quad \frac{\partial J_z^*}{\partial z}=0.$$

Thus, by Eqs. 9 and 11,

$$\frac{d^2J_z^*}{dr^2}+\frac{1}{r}\frac{dJ_z^*}{dr}-i\omega\mu\sigma J_z^*=0. \quad (12)$$

The general solution of this differential equation is

$$J_z^*=A^*J_0(\sqrt{-i\omega\mu\sigma}\,r)+B^*Y_0(\sqrt{-i\omega\mu\sigma}\,r). \quad (13)$$

Since Y_0 becomes infinite on the axis, the second term of Eq. 13 cannot be used, and the solution is

$$J_z^* = J_s \frac{J_0(\sqrt{-i\omega\mu\sigma}\, r)}{J_0(\sqrt{-i\omega\mu\sigma}\, a)}, \tag{14}$$

where J_s is the current density at the surface. The Bessel functions may be expressed in terms of *ber* and *bei* functions or in terms (9) of amplitude M_0 and angle θ. The above is one of the few cases where the vector Laplacian happens to give the same form of expression as the scalar Laplacian.

In the other example, we take a long cylindrical rod of metal and induce alternating currents in it by means of an exciting coil about the rod. Equation 11 applies, just as in the preceding example. From physical considerations,

$$\mathbf{J} = \mathbf{a}_\psi J_\psi(r).$$

Thus, from Eqs. 9 and 11,

$$\frac{d^2 J_\psi^*}{dr^2} + \frac{1}{r}\frac{dJ_\psi^*}{dr} - \left(\frac{1}{r^2} + i\omega\mu\sigma\right) J_\psi^* = 0. \tag{15}$$

The general solution is

$$J_\psi^* = A^* J_1(\sqrt{-i\omega\mu\sigma}\, r) + B^* Y_1(\sqrt{-i\omega\mu\sigma}\, r).$$

Eliminating the function of the second kind as before, we obtain

$$J_\psi^* = J_s \frac{J_1(\sqrt{-i\omega\mu\sigma}\, r)}{J_1(\sqrt{-i\omega\mu\sigma}\, a)}. \tag{16}$$

The current distribution for skin effect is quite different from that for induction heating, one employing the zero-order Bessel function while the other uses the first-order function. Yet the same Helmholtz equation applies in each case; and if the mistake had been made of using the scalar Laplacian instead of the vector Laplacian, Eq. 14 would have appeared to be the solution in both cases.

There are numerous ways of handling electromagnetic problems, using retarded potentials, vector potentials, integral equations; but a definite advantage results from employing the same method over the whole field of electrodynamics instead of using a different approach for each problem. Such a unified treatment takes the vector Laplacian as its cornerstone and considers each steady-state a-c. problem as an

example of the vector Helmholtz equation:

$$\bigstar \mathbf{E}^* + \gamma^2 \mathbf{E}^* = 0$$

or (17)

$$\bigstar \mathbf{H}^* + \gamma^2 \mathbf{H}^* = 0.$$

Progress in this direction has been hampered in the past by lack of definite knowledge of the vector Laplacian, and even by confusion of the vector Laplacian with the scalar Laplacian. By use of Eq. 9, however, we can now express the Helmholtz equation in any coordinate system. All skin-effect and eddy-current problems are formulated as Eq. 11 with $\gamma^2 = -i\omega\mu\sigma$, while waveguides and antennae are formulated by the same equation with $\gamma^2 = \omega^2\epsilon\mu$.

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NOTES FROM THE NATIONAL BUREAU OF STANDARDS *

VIBRATION PICKUP CALIBRATOR

An instrument which calibrates vibration pickups and accelerometers rapidly and reliably has recently been devised by W. A. Yates and M. Davidson of the National Bureau of Standards at the request of the Navy Bureau of Ships. The device operates on the principle of the mutual inductance transducer, which was originally developed by the Bureau to measure small displacements and has since been applied in a number of NBS measurement instruments. The instrument has an accuracy of 5 per cent over wide frequency and amplitude ranges, and can easily be standardized using a calibrated displacement such as that provided by a precision dial gauge.

In recent years the widespread use of vibration pickups for simultaneously monitoring a large number of points has introduced a serious calibration problem. Analysis of the problem has been complicated by the higher frequency components of vibration and resonant properties of the pickups. The increase in the number of pickups has emphasized the need for a rapid, reliable means of calibration over wide ranges of frequency and amplitude. Many of the calibration techniques now in use are limited in bandwidth and are difficult to standardize. Others require tedious point-by-point measurement and involve a considerable problem in data reduction. The NBS instrument was designed to overcome these deficiencies.

The vibration sensing element of the NBS instrument is a stable non-contacting displacement transducer of mutual-inductance type, developed by M. L. Greenough of the NBS staff for use in other instruments.[1] The transducer utilizes the principle that the field surrounding a coil energized with alternating current will induce current in a nearby coil. The amount of current thus induced can be controlled by placing a conducting shield at various distances from the latter coil. In the Bureau's calibrator, vibration of a non-magnetic conductive surface with respect to a probe containing the two coils and a carrier detector for the secondary winding generates an a-c. component of output voltage proportional to the amplitude of vibration. In the normal use of the instrument, this a-c. component is measured by means of a stable vacuum-tube voltmeter, producing a reading pro-

* Communicated by the Director.

[1] "Technical Details of an Electronic Micrometer," *Electronics*, Vol. 20, No. 11, November, 1947.

portional to the amplitude of vibration. It will respond to frequencies from 10 to 20,000 cps. and amplitudes from 10 microinches to 0.01 in. This is an acceleration range of 2×10^{-4}g. to 4×10^{5}g.

The instrument is standardized by chopping the detected d-c. voltage increment produced by a standard mechanically measured displacement change, in this case 0.02 in., into a square wave. Fed into the same a-c. peak-to-peak voltmeter on the 0.01-in. range, the square wave is equivalent to a 0.01-in. peak amplitude of vibration. The sensitivity of the voltmeter is then adjusted to obtain a full-scale reading. The choice of a displacement as an absolute standard for the instrument was made primarily because of the ease with which it can be reproduced without special equipment.

The use of a displacement transducer in this application presents both advantages and problems. The principal difficulty encountered is that of mounting the probe, since the mount itself must be free of ambient vibrations if the full capabilities of the instrument are to be realized. This requirement is met by using sturdy, rigid brackets. An advantage of this type of transducer is that it introduces practically no loading on the vibration generator. Thus, the generator can be designed solely on the basis of the loading imposed by the pickups to be calibrated, and significant savings can be achieved in equipment for high-frequency calibration.

The engineered instrument consists of the transducer in the form of a probe and an encased chassis which contains the electronic circuitry and to which the probe is attached by means of a cable. Direct meter indications of the peak amplitudes of sinusoidal vibrations are given. The operation of the instrument requires that the probe be mounted at a fixed distance from the mean position of the vibrating surface. For this purpose a meter indication of the probe-to-surface spacing is provided, enabling the operator to make the necessary settings quickly. This adjustment is not nearly as critical as the adjustment required by capacitive types of vibration transducers.

NOTE: For additional information on the vibration pickup calibrator, see "Wide-range Calibrator for Vibration Pickups," by W. A. Yates and M. Davidson, *Electronics*, Vol. 26, No. 9, September, 1953.

ADAPTABLE ELECTRONIC CHASSIS

In response to the need for a components chassis that would lend itself to varied and changing electronic designs, I. Rotkin and J. Guarracini of the National Bureau of Standards have developed a widely adaptable chassis that is both economical and convenient. The design of the new chassis includes a rectangular frame made of $\frac{3}{8} \times \frac{1}{16}$-in. steel angle and sets of flat plates that are fitted to the frame with screws. The frames vary in size so that chassis may be made up as small 3×4-in. boxes, or $3 \times 13 \times 16$-in. models, or even whole networks of different-sized chassis.

Conventional electronic chassis, normally built with five sides, often impose restrictions on the movement of tools used to drill and punch the required holes and recesses. After the components have been installed in the chassis and the experimental circuit tested, either a relatively expensive piece of equipment must be thrown away or valuable storage space must be used for an item that is only potentially useful. Even during the development stages of the circuit, the design of conventional chassis does not lend itself to exposure of the circuit wiring and tube sockets to facilitate probing and rewiring. Sometimes a great simplification is possible in the construction of equipment if several "breadboard" models can be pieced together, but this is a difficult task requiring complex mechanical structures if the components are mounted in standard chassis.

The chassis developed by NBS are produced in four standard sizes, all 3 in. high: 16 × 13 in., 13 × 8 in., 8 × 4 in., and 4 × 4 in. Flat cover plates are drilled with holes that match screw-holes in the frames. The dimensions of the chassis and plates were chosen so that the long side of each chassis matches the short side of the next larger size. When desired, any of the six side plates may be left blank or discarded entirely; thus, ventilation may be obtained for circuits requiring air circulation. No restrictions are placed on the kind of material from which the flat plates are made. Consequently, it is possible to eliminate much of the component insulation required when using all-metal chassis.

In developing a circuit, the components may be assembled to "breadboard" style on one or more flat plates before final mounting on a suitable frame. This procedure facilitates and simplifies the often laborious details of drilling, punching, deburring, or nibbling. Once the units have been mounted in the plates, they may be screwed onto the frames with all the wiring and tube sockets on the open (outer) side of the plate exposed to the probing of the test equipment. If the design and craftsmanship permit, these same plates may later be reversed; the wiring will then be protected, the tubes will be accessible for replacement, and the completed unit is ready for actual operation.

If a component is a prototype or has become obsolete, only the plate containing the circuit in question need be removed from the frame and replaced with the improved circuit. The discarded plate can then be stripped of the easily removable components and stored in a shallow drawer or cabinet until a similarly patterned plate is needed again. If desired, whole clusters of these versatile chassis may be assembled around or on top of a larger chassis—the frames are sufficiently standardized to permit this. In addition, the spacing between the holes permits the mounting of commercially available bakelite terminal strips.

NOTE: The Richards Company of Arlington, Virginia, now making the chassis under contract to the National Bureau of Standards, has contributed several design improvements that have been incorporated in the final model.

THE FRANKLIN INSTITUTE

MINUTES OF STATED MEETING, November 18, 1953

The Stated Monthly Meeting of The Franklin Institute was held on November 18, 1953, in the Lecture Hall. S. Wyman Rolph, President, called the meeting to order at 8:20 P.M. Approximately 370 persons attended.

The President asked for approval of the minutes of the Stated Meeting in October, which were printed in the November JOURNAL. There being no corrections or additions, they were approved as submitted.

The Secretary reported the following elections to membership since April 30th:

Active	194
Associate	191
Student	135

and a total membership, including Company, and Library privileges, of 6,825 as of October 31, 1953.

The President then recognized Morton Gibbons-Neff, Chairman of the Membership Committee, who, in presenting Charles H. Howson to the President, outlined Mr. Howson's many achievements. At the conclusion of Mr. Neff's introduction, the audience arose and gave Mr. Howson a spontaneous ovation. The President presented Mr. Howson with a gold key in recognition of his fifty years of continuous membership in The Franklin Institute.

The President then recognized Kennard N. Ware, President of The Philadelphia Patent Law Association, who expressed great pleasure in the success of these meetings. Mr. Ware called upon Joseph Gray Jackson, who introduced "The Trial of Kovacs *v.* Fishgill," a vignette of a patent law infringement suit under the new Patent Law. William P. Cole acted as Counsel for the Plaintiff and Roy C. Hackley for the Defendant. Following the presentation of the case, the Judges—Giles Rich, Charles H. Howson, and J. D. Myers—held their judicial discussion on the pros and cons of the case in the presence of the audience, and at the end Chief Judge Rich announced that their "decision was postponed until the next term."

The interesting meeting adjourned at 10:30 P.M.

HENRY B. ALLEN,
Secretary

JOURNAL OF THE FRANKLIN INSTITUTE

The following papers will appear in this JOURNAL within the next few months:

CONN, WILLI M.: Recent Progress in Solar Furnaces for High-Temperature Research and Development Work.

PISTER, KARL S.: The Airy Stress Function in Curvilinear Coordinates with Application to the Uniform Flexure of a Naturally Curved Spiral Beam.

SEAL, PHILIP M.: Analysis of Network Response to Periodic Waves.

MOON, PARRY AND DOMINA EBERLE SPENCER: The Coulomb Force and the Ampere Force.

BULAND, R. N.: Analysis of Nonlinear Servos by Phase-Plane-Delta Method.

TOMOVICH, RAJKO: A Versatile Electronic Function Generator.

POWLEY, HOMER S.: Rapid Estimation Method for Long-Pointed Projectile Trajectories.

MOON, PARRY AND DOMINA EBERLE SPENCER: A New Electrodynamics.

COMMITTEE ON SCIENCE AND THE ARTS

(Abstract of Proceedings of Stated Meeting held Wednesday, November 11, 1953.)

HALL OF THE COMMITTEE,
PHILADELPHIA, NOVEMBER 11, 1953.

MR. HOWARD STOERTZ in the Chair.

The following report was presented for final action:

No. 3272: Newcomen Medal.

This report recommended the award of The Newcomen Medal to WILL H. ROWAND, of Plainfield, New Jersey, "In consideration of his design and development of a device for separating steam from water known as a Cyclone Steam Separator, which makes possible the use of boilers operating at greatly increased pressures while maintaining natural circulation."

JOHN FRAZER,
Secretary to Committee

MEMBERSHIP

ACTIVE MEMBERS ELECTED AT THE MEETING OF THE BOARD OF MANAGERS

November 18, 1953

ACTIVE FAMILY

Hally P. Johns
Wilbur H. Norton
Samuel M. Silver
William J. Tanseer
Ray H. Timmons

ACTIVE

Leonard Binstock
William F. Boyer
Hyman N. Caplan
E. G. Carlson
William D. Connon
Rowland G. Dietz
Myriam R. Eriksson
Paul A. Fodor, Jr.
Elmer W. Hipp
Howard P. Klair
Russell Kreinberg
William B. Leighninger
Abraham Mackler
J. J. McKenna
Adolph F. Petzold

ACTIVE NON-RESIDENT

Charles H. Welling

NECROLOGY

H. B. Dunkle '40
S. Griswold Flagg '46
Edwin D. A. Frank '19
Edwin P. Hubbell, Ph.D., D.Sc. '39
Mrs. Arthur B. Huey '36
Lloyd B. Jones '50
John Tracy Lay '23
Etta W. Mastbaum '36
John H. Packard, 3rd '42
Mrs. Anthony P. Ralli '38
Christian W. Reed '48
G. N. Sieger '29

LIBRARY

The Committee on Library desires to add to the collections any technical works that members may wish to contribute. Contributions will be gratefully acknowledged and placed in the Library. Duplicates received will be transferred to other libraries as gifts of the donor.

Photostat service. Photostat prints of any material in the collections can be supplied on request.

The Library and reading room are open from 9 A. M. until 5 P. M. on Mondays, Tuesdays Fridays and Saturdays; 2 P. M. until 10 P. M. on Wednesdays and Thursdays.

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GERASSIMOW, S. G.; DUDNIKOW, E. G. AND TSCHISTJAKOW, S. F. Automatische Regelung von Kesselanlagen. 1952.

KRONGAUS, S. D. Wärmeversorgung aus Zentralen Kesselanlagen. 1952.

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NOTES FROM THE FRANKLIN INSTITUTE MUSEUM

A. C. CARLTON, EXECUTIVE DIRECTOR

WRIGHT BROTHERS' MODEL B, NO. 13

When a museum contemplates the formation of an aviation section, the first obstacle which presents itself is that of space. Unless this can be overcome by the provision of hangars, the alternative is to make a collection of models. Fortunately there is a large number of aviation enthusiasts who have developed a marked skill in model making and this assures a flow of appropriate models to keep the collection up to date. The one difficulty which now arises is to fill the gaps so that the collection can be carried back in time to illustrate the earliest phases of the science. The Franklin Institute Museum is particularly happy in having secured a well furnished and representative collection of scale models to show the progress of aviation from its modern inception.

It does not seem possible to appreciate the development of aviation without some knowledge of the pioneer efforts of men like Otto Lilienthal in Germany and Octave Chanute in the United States. It was the basic knowledge acquired by these men which guided the Wright Brothers when they began to supplement it by their laboratory experiments and practical glider flights. They were convinced they had the right design before they added the power plant to make sustained flight.

But models cannot tell the complete story. There must be some actual planes, and if any of them should have a history, so much the better. Among the actual planes in our Aviation Section are two of historic interest. One is the plane in which Amelia Earhart made her first solo flight across the Atlantic, and the other is an original Wright Model B, number 13 of the honorable line of planes which bore the name of the famous brothers. It is believed this latter is the oldest plane in existence which is still capable of being flown, if anyone accustomed to the sturdy structures of today should possess the courage and hardihood to test its apparently flimsy construction. Its capacity to fly is no idle boast, although it was last taken into the air in 1934 at the Camden Airport.

The sight of this plane invariably provokes a flood of questions relating to the duration of the first flight and the altitude reached. On the distance covered there never has been a doubt. On December 17, 1903, four flights were made, each of the two brothers making two, and the longest distance flown was 852 feet in 59 seconds. The hitherto dubious matter of altitude has now been settled through the publication of Orville Wright's diary, in which he mentions that on the third flight, he flew at a height of 12 to 14 feet.

The Model B plane differs slightly from that in which the initial flights were made. The most notable changes are the provision of seats (in the first model the pilot lay prone), the modified elevator assembly, and the replacement of skids by landing wheels. Number 13 was flown locally in 1912–1914 by Grover C. Bergdoll, a well known early flyer. The pilot made 748 flights in this machine without mishap, at a top speed of 45 miles per hour. Many visitors to the Museum

The Wright Brothers' first airplane.

have spoken of the terror they endured when the pilot swooped over their heads when they were walking in Fairmount Park.

In a similar biplane, C. P. Rodgers made the first transcontinental flight in 1911, from Long Island to California. In sharp contrast to the speeds attained today, Rodgers required forty-nine days and sixty-eight hops to complete his flight.

NOTES FROM THE FRANKLIN INSTITUTE LABORATORIES FOR RESEARCH AND DEVELOPMENT

NICOL H. SMITH, DIRECTOR

TESTING OF A HYDRAULIC MOTOR

BY

R. H. MARVIN

Hydrostatic power drive transmissions, used in both industrial and military applications, are often composed of one variable displacement machine and one fixed displacement machine suitably coupled by high-pressure hydraulic lines. The displacement of the variable displace-

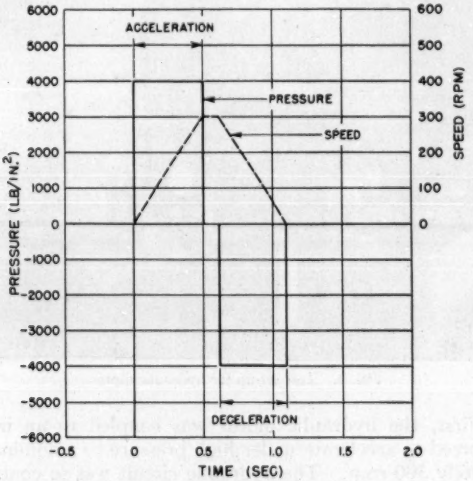


FIG. 1. Typical duty cycle.

ment machine regulates the velocity of the output shaft of the hydraulic motor, thus giving a fine adjustment on the motor speed. Certain applications of this type of transmission require that the hydraulic motor operate at very low rotational speeds. This would correspond to very small displacements of the variable displacement unit and small fluid flow in the hydraulic lines. Some commercial hydraulic motors are not recommended for operation below certain minimum speeds.

The reason for this limitation may be poor efficiency at low speeds, the absence of certain desirable centrifugal effects at low speed or the failure of certain bearing elements to develop hydrodynamic films at low speed.

For a particular application of a hydrostatic transmission, low rotation speeds of the hydraulic motor were required. In the particular hydraulic motor considered for this application it was believed that the failure of certain bearing elements to form hydrodynamic films at low rotational speeds under high torque requirements would be injurious to the bearing elements. A test was devised to check out the performance of the hydraulic motor at low rotational speeds under the influence of the maximum hydraulic pressure. This test was divided into two

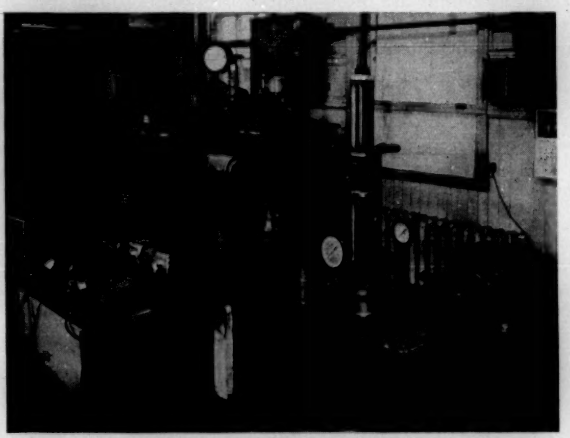


FIG. 2. Test set-up for hydraulic motor.

phases. First, the hydraulic motor was coupled to an inertia load and was forced to accelerate under high pressure to a nominal speed of approximately 300 rpm. The hydraulic circuit was so controlled that the energy stored in the inertia load at 300 rpm. was further used to drive the motor as a pump with the output of the pump passing through a high pressure relief valve. The pressures during acceleration and deceleration of the flywheel were adjusted to be the same. Electronic timers were incorporated in the hydraulic circuit so that the starting and stopping cycle could be repeated at a definite period. Figure 1 shows a typical duty cycle for this type of loading.

The second test consisted of running the hydraulic motor at low rotational speed with a brake on the output of the motor. In this

case the steady rotation of the motor was kept low enough so that no hydrodynamic film could be formed on the bearing surfaces. The brake was adjusted so that the pressure within the hydraulic motor was near its maximum allowable value. This test was run for various speeds of rotation, the lowest being in the neighborhood of 10 rpm. Figure 2 shows a photograph of the over-all set-up for both tests.

After a period of starting and stopping and a continuous run at slow speed the hydraulic motor was disassembled and inspected for possible damage. The points believed to be critical from the bearing and wear standpoint appeared to be in excellent condition and it was concluded that the performance of the hydraulic motor is suitable at low rotational speeds under high output torques. Although it is not likely that hydrodynamic films were formed under these conditions of operation it appeared that the selection of materials for the bearing parts was suitable for operation with the kind of lubrication that prevailed.

NOTES FROM THE BARTOL RESEARCH FOUNDATION

W. F. G. SWANN, DIRECTOR

REYNOLDS NUMBERS AND ASSOCIATED MATTERS

BY

W. F. G. SWANN

In connection with his advisory work with The Franklin Institute Laboratories for Research and Development, the Director has developed a theory dealing with the general problem of flow of viscous fluids through a circulatory system, and has developed a theorem which formulates the conditions which determine the nature of such flow. The solution is unique only when some viscosity exists, and the time taken to reach the unique solution depends upon the magnitude of the viscosity.

The presentation also contains a modified form of the development of the theory of Reynolds Numbers in application to hydrodynamical problems.

INELASTIC SCATTERING OF FAST NEUTRONS BY BISMUTH AND NICKEL *

BY

M. A. ROTHMAN AND C. E. MANDEVILLE

Monoenergic neutrons of energy 3.9 Mev have been scattered from bismuth and nickel. Using scintillation spectrometry, the energies of the gamma rays excited in the inelastic scattering process have been determined. For bismuth, gamma rays of quantum energies 0.91, 1.63, 2.60 and 3.35 Mev were detected. A gamma ray at 1.36 Mev was excited in nickel and possibly another at 0.90 Mev.

* Assisted by the Joint Program of the ONR and the AEC.

ELECTRONIC PHENOMENA IN THORIUM OXIDE *

BY

O. A. WEINREICH,[1] W. E. DANFORTH AND D. L. GOLDWATER

The electronic phenomena in thorium oxide fall into two rather distinct classifications depending upon whether the specimen concerned is in the "low oxygen" or the "high oxygen" state.

The former state is the one which pertains to thermionic applications; conductivity is apparently activated by free thorium produced by electrolysis, although final proof of this has not as yet been obtained. Thermoelectric parameters in the low oxygen state are difficult to

determine on account of disturbing time effects, presumably of ionic origin. The polarity of the Seebech effect, however, is in nearly all cases consistent with n-type conduction.

High oxygen crystals, measured in oxygen atmospheres (all measurements referred to are at elevated temperatures) show relative freedom from electrolysis, although some time changes are present. Seebech effect is stable and shows p-type conduction. Activation energies determined by conductivity and Seebech effect, respectively, are in agreement. Energy gaps of the order of 1 or 2 volts are obtained from conductivity measurements; an intrinsic gap of 3.9 volts is indicated by ultraviolet absorption. Hall studies in both states of oxygen content are contemplated.

* Assisted by the ONR and the AEC.
[1] Now with Tung-Sol Electric, Inc.

THE DISINTEGRATION OF Mo^{99} *

BY

JAGDISH VARMA,[1] BABULAL SARAF[1] AND C. E. MANDEVILLE

The radiations of Mo^{99} and Tc^{99m} have been re-investigated by means of scintillation spectroscopy. Employing single channel pulse height analyzers in coincidence, it has been established that a triple cascade of gamma rays 740 Kev → 40 Kev → 140 Kev occurs. The 740 Kev radiation is also coincident with a gamma ray at 180 Kev by an alternate branch of de-excitation which is equally probable. Radiation at 780 Kev is also present but is non-coincident with other gamma rays. From these data, a disintegration scheme can be constructed. A gamma ray of energy 372 Kev was also detected, and, although it appeared to have the proper half-period to be associated with Mo^{99}, was found to be not in immediate coincidence with beta rays or gamma rays, suggesting that it might be related to an impurity.

* Assisted by the Joint Program of the ONR and the AEC.
[1] Research Fellow, Bartol; permanent address, Morena (M.B.) India.
[2] Research Fellow, Bartol; on leave of absence from Agra College, Agra, India.

PROPERTIES OF THE PRIMARY COSMIC RADIATION NEAR THE GEOMAGNETIC EQUATOR *

BY

M. A. POMERANTZ[1]

A program of investigations of the cosmic radiation at very high altitudes was conducted in India during 1952–53. A number of different experiments were performed during the course of the expedition in which 29 balloon-borne instruments were released at two stations.

Measurements of the dependence of intensity upon altitude were obtained at Aligarh (geomagnetic latitude 18° N) and Bangalore (geomagnetic latitude 3° N) with vertical quadruple coincidence counter trains containing various thicknesses of interposed absorber (4.0 cm. Pb, 7.5 cm. Pb, 18.0 cm. Pb) and in some instances with similar trains oriented horizontally. These instruments were identical with those previously utilized extensively at Swarthmore, Pa., and at Churchill, Manitoba (geomagnetic latitude 69° N).

The experiments have revealed the existence of an appreciable latitude effect between 18° and 3°. This is contrary to the earlier results of Millikan and co-workers, who reported that, in accordance with their atom-annihilation theory of the origin of the cosmic rays, the primary energy spectrum exhibits a banded structure such that no change in intensity occurs between these two latitudes. In an integral energy distribution of the form $I(>E) = kE^{-\gamma}$, the value of γ is approximately 1.5 for $E = 12$ Bev, as compared with $\gamma \approx 1.0$ for lower energies (12 Bev $> E >$ 4 Bev).

The absorption mean-free-path in lead for the higher energy protons ($E >$ 14 Bev) admitted near the equator is the same as that for the less energetic particles ($E >$ 1.5 Bev) entering the atmosphere at Swarthmore. The presence near the "top of the atmosphere" of a group of low energy protons is indicated at low latitudes. These had not previously been detected at higher latitudes because of the predominance of primaries having energies near the geomagnetic cut-off. Various other properties of the radiation can be deduced from the data, a detailed analysis of which is in progress.

* Assisted by the Joint Program of the ONR and the AEC. India Expedition sponsored by the National Geographic Society.

[1] Visiting Professor, Muslim University, Aligarh, U.P., India, during 1952–53 under the Fulbright Program.

SECONDARY ELECTRON EMISSION PRODUCED BY HIGH ENERGY PRIMARY ELECTRONS *

BY

J. F. MARSHALL, M. A. POMERANTZ AND R. A. SHATAS

The Bartol linear accelerator has been utilized for providing a beam of high energy electrons for investigations of the secondary electrons produced by the bombardment of metal targets. A new technique, which permits observations of the secondaries emerging from both the entrance and exit faces of a thin target through which the primaries penetrate with negligible energy loss, has been devised. Preliminary measurements of the total yield from both faces have been obtained. For thin aluminum foils (thickness = 0.0002 in.–0.001 in.) the emission of secondaries having energies less than 300 e. v. amounts to approxi-

mately 3 per cent of the primary current, and there is no measurable dependence upon target thickness. The nature of the variation of yield with thickness is now being investigated with thicker targets.

The energy distribution of the secondaries produced by 1.5 Mev primaries is apparently similar to that observed when the bombarding energy is hundreds of volts, that is, the maximum of the differential energy distribution occurs at less than 10 e. v. Measurements involving the application of a magnetic field have revealed the existence of a considerable tail of high energy secondary electrons (δ-rays) of surprisingly large magnitude. The theoretical significance of all of the observed phenomena is being studied.

* Assisted by the Office of Naval Research and the Office of Ordnance Research.

THE VARIATION WITH LATITUDE OF THE ALPHA PARTICLES IN THE PRIMARY COSMIC RADIATION *

BY

G. W. McCLURE AND M. A. POMERANTZ [1]

The primary alpha-particle intensity has been measured by means of a balloon-borne instrument which essentially comprises a vertical quadruple-coincidence counter train containing an interposed high pressure ionization chamber beneath which is placed a lead absorber. The lead is of sufficient thickness (4 cm.) to preclude the penetration through the train by a non-relativistic particle. Events in which the particle actuating the coincidence counters produces an amount of ionization in the chamber exceeding 31_{min} were recorded. Taking into account statistical fluctuations in the primary ionization process (Landau spread), single protons are eliminated, and all particles having $Z > 1$ (predominantly He^4 nuclei) are observed with this bias setting. The total intensity was also measured by utilizing a switching arrangement to remove the ionization chamber from the circuit at predetermined altitudes, and by separate flights.

These instruments have been sent aloft at Swarthmore, Pa. (geomagnetic latitude 52° N), Aligarh, India (geomagnetic latitude 18° N) and Bangalore, India (geomagnetic latitude 3° N.) Considerations based on the results of the experiment performed at the Galapagos Islands (as described in an accompanying note) reveal that a rather detailed analysis is required to arrive at conclusions regarding the flux of primary helium nuclei. Preliminary analysis of the data indicates that alpha particles constitute at least 20 per cent of the primary cosmic radiation incident in the vertical direction near the geomagnetic equator.

* Assisted by the Joint Program of the ONR and the AEC. India Expedition sponsored by the National Geographic Society.

[1] Visiting Professor, Muslim University, Aligarh, U.P. during 1952–1953, under the Fulbright Program.

MEASUREMENT OF SPECIFIC IONIZATION OF PRIMARY COSMIC RAYS NEAR THE GEOMAGNETIC EQUATOR *

BY

G. W. McCLURE

During the month of September the Bartol Foundation participated in an equatorial expedition conducted by the Office of Naval Research to facilitate the accumulation of new information on the properties of the more energetic primary cosmic rays.

The measuring instrument used on this trip was a refined form of an apparatus of earlier design used in India during the past year. In addition to a Geiger-Mueller counter telescope with interposed ionization chamber, the newer instrument contained a tray of counters to register the occurrence of showers and an oscillograph-camera recorder to register the specific ionization of each particle traversing the counter train. Among the items of information supplied by the improved instrument are the following:

1. That a large fraction ($\sim 20\%$) of the vertically-oriented particles at 12 mm. Hg ionize too heavily to be *primary* protons and too lightly to be *primary* He nuclei. The evidence suggests production of slow highly-ionizing protons.
2. That at least 30 per cent of all primary particles which traverse the counter-train are accompanied by secondaries (produced either in the air above the instrument or in the material within the telescope solid angle) which traverse the ionization chamber together with the primary.

Each of these findings has an important bearing on the interpretation of results obtained at several different latitudes with the older instrument, and seems to rule out the possibility that the primary α-particle flux can be determined with the precision previously expected of the present type of instrument.

The experimental results are now being tested for consistency with photographic emulsion data on high-energy nuclear interactions.

* Assisted by the ONR and the AEC.

NOTES FROM THE BIOCHEMICAL RESEARCH FOUNDATION

ELLICE McDONALD, DIRECTOR

CARBOHYDRATE ANALOGS AS ANTAGONISTS OF GLUCOSE IN CARBOHYDRATE METABOLISM OF YEAST

BY

GLADYS E. WOODWARD, FRANCIS B. CRAMER AND MARIE T. HUDSON

Further studies with carbohydrate analogs have been carried out in continuation of our search for inhibitors of carbohydrate metabolism which might eventually prove effective in the control of cancer. The yeast cell, whose carbohydrate metabolism is in many respects similar to that of the cancer cell, has been used as the test system, since this provides a simple and rapid means of screening a large number of compounds.

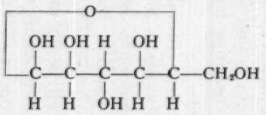
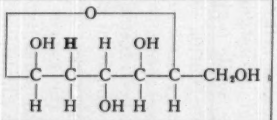
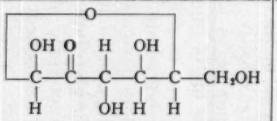
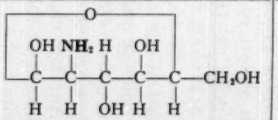
A characteristic of the cancer cell is its unusual ability to use glucose by the process of anaerobic glycolysis from which it obtains a large part of the energy required for growth. On the premise that a structural analog of glucose might inhibit this process by competing with glucose, we have tested numerous analogs of glucose as possible inhibitors. 2-Desoxy-D-glucose and D-glucosamine have been shown previously (1,2) to act as competitive inhibitors of glucose in anaerobic fermentation, the process in yeast which corresponds to the process of anaerobic glycolysis in the cancer cell. 2-Desoxy-D-glucose has also been shown to be effective in inhibiting the anaerobic glycolysis of surviving rat tumor slices (3), while D-glucosamine has been reported (4) to prolong the life of tumor-bearing mice.

The effectiveness of other glucose analogs in inhibiting various phases of the carbohydrate metabolism of yeast is reported here. A few fructose analogs have also been tested, since glucose is converted to the fructose configuration in the form of fructose phosphates in the early stages of the glycolytic process.

Another characteristic of the cancer cell is its rapid rate of cell division and the consequent demand for components of nucleic acids. Ribose-5-phosphate, a carbohydrate component of nucleic acids, can be formed from glucose by an aerobic metabolic pathway (5), the first step, after phosphorylation of glucose, being oxidation of glucose-6-phosphate to 6-phospho-gluconic acid. Therefore we have tested analogs of gluconic acid, ribose and desoxyribose (also a normal constituent of nucleic acids) as possible inhibitors of nucleic acid formation, and consequently of growth.

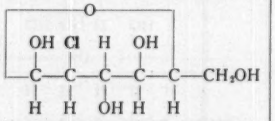
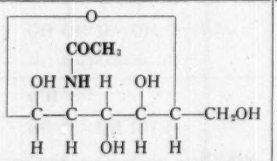
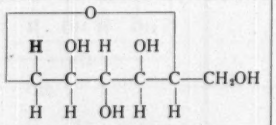
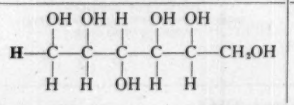
Most of the analogs studied were prepared in this laboratory, while a few were obtained from commercial sources. The effect of an analog on anaerobic fermentation, aerobic fermentation, respiration and growth of yeast was measured as described in the studies with 2-desoxy-D-glucose (1,6). The results, together with the structural relationship of the analog to the parent substance, are given in Tables I and II.

TABLE I.—*Effect of Glucose and Fructose Analogs on Carbohydrate Metabolism of Yeast.*

Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect of Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated	Anaerobic Fermentation with .05M Fructose .05M Analog
			% inhibition	% inhibition	% inhibition		% inhibition
D-Glucose							
Glucose Analogs Differing only on #2 C-atom	2-Desoxy-D-glucose[1]		76–80	75–82	0	50% inhibition at .02:1	90
	D-Glucosone[1]		56	79–84	64–83	50% inhibition at 2:1	
	D-Glucosamine[2]		40	0	0	50% inhibition at 1:1 21% stimulation at 0.1:1	55

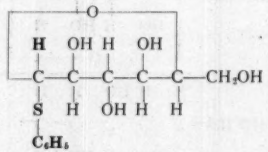
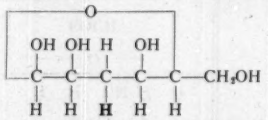
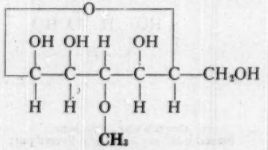
[1] Prepared by one of us (F.B.C.).
[2] Obtained from Pfanstiehl Chemical Co.

TABLE I.—*Continued*

Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect of Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated	Anaerobic Fermentation with .05M Fructose .05M Analog
			% inhibition	% inhibition	% inhibition		% inhibition
Glucose Analogs Differing only on #2 C-atom (*continued*)	2-Chloro-2-desoxy-D-glucose[2]		12				
	N-Acetyl-D-glucosamine[4]		0	0	0	No inhibition at 2:1 74% stimulation at 2:1	0
Glucose Analogs Differing only on #1 C-atom	Polygalitol[1]		0	0	0	No inhibition at 2:1	
	D-Sorbitol[5]		0	0	0	No inhibition at 2:1	

[1] Prepared by Francis E. Reinhart of this laboratory.
[4] Obtained from Dougherty Chemicals.
[5] Obtained from Eastman Kodak Co.

TABLE I.—*Continued.*

Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect of Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated	Anaerobic Fermentation with .05M Fructose .05M Analog
			% inhibition	% inhibition	% inhibition		% inhibition
Glucose Analogs Differing only on #1 C-atom (*continued*)	Phenyl-β-D-glucothioside[5]		0				
Glucose Analogs Differing only on #3 C-atom	3-Desoxy-D-glucose[5]		0				
	3-Methyl-D-Glucose[6]		0	0	0	No inhibition at 2:1	

[6] Prepared by one of us (G. E. W.).

TABLE I.—*Continued.*

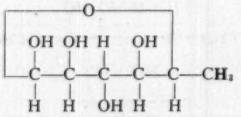
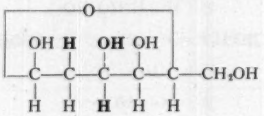
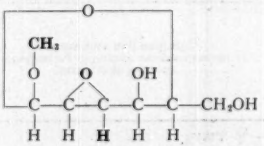
Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect of Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated	Anaerobic Fermentation with .05M Fructose .05M Analog
			% inhibition	% inhibition	% inhibition		% inhibition
Glucose Analogs Differing only on #6 C-atom	iso-Rhamnose[1]		0	0	0	No inhibition at 2:1	
Glucose Analogs Differing on #2 C-atom with Additional Difference	2-Desoxy-D-allose[2]		0				
	2,3-Anhydro-α-methyl-D-alloside[2]		0				

TABLE I.—*Continued.*

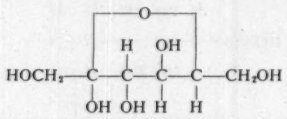
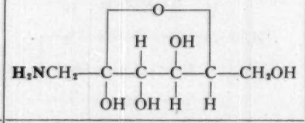
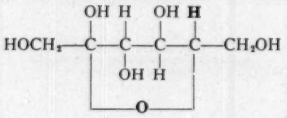
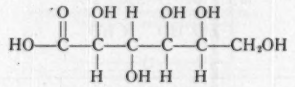
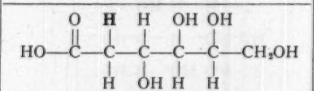
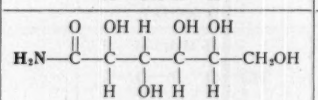
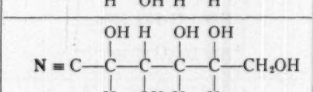
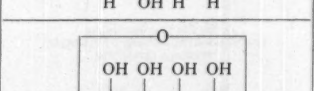
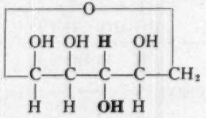
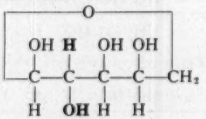
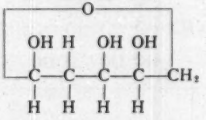
Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect of Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated	Anaerobic Fermentation with .05M Fructose .05M Analog
			% inhibition	% inhibition	% inhibition		% inhibition
D-Fructose							
Fructose Analogs	iso-Glucosamine[1]		22	0	0	No inhibition at 2:1 140% stimulation at 0.2:1 to 2:1	35
	L-Sorbose[6]		0	0	0	No inhibition at 2:1	

TABLE II.—*Effect of Gluconic Acid, Ribose and Desoxyribose Analogs on Carbohydrate Metabolism of Yeast.*

Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect on Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated
			% inhibition	% inhibition	% inhibition	
D-Gluconic Acid						
Gluconic Acid Analogs	2-Desoxy-D-gluconic acid[1]		0	0	0	No inhibition at 1:1 51% stimulation at 0.25:1 to 1:1
	D-Gluconamide[1]		0	0	0	No stimulation at 2:1 100% stimulation at 2:1
	D-Glucono-nitrile[1]		0	0 (70% stimulation)	40–47	50% inhibition at .01:1
D-Ribose[2]			0	0	0	No inhibition at 2:1 37% stimulation at 2:1

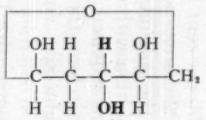
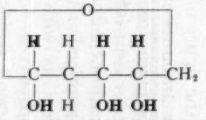
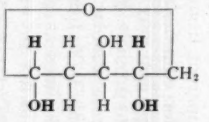
[1] Prepared by one of us (F. B. C.).
[2] Obtained from Schwarz Laboratories.

TABLE II.—*Continued.*

Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect on Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated
			% inhibition	% inhibition	% inhibition	
Ribose Analogs	D-Xylose[2]		0	0	0	No inhibition at 2:1
	D-Arabinose[1]		0	0	0	No inhibition at 2:1
2-Desoxy-D-Ribose[1]			0	0	0	

[2] Obtained from Fisher Scientific Co.

TABLE II.—*Continued.*

Type of Substance	Analog Tested	Structural Formula (indicating difference between parent substance and analog)	Effect on Analog on: Anaerobic Fermentation with .05M Glucose .05M Analog	Aerobic Fermentation with .02M Glucose .02M Analog	Respiration with .02M Glucose .02M Analog	Growth in 2% Glucose at Analog:Glucose Ratio Designated
			% inhibition	% inhibition	% inhibition	
Desoxy-ribose Analogs	2-Desoxy-D-xylose[1]		0	0	0	No inhibition at 2:1 67% stimulation at 2:1
	2-Desoxy-L-ribose[1]		0	0	0	No inhibition at 2:1
	2-Desoxy-L-xylose[1]		0	0	0	No inhibition at 2:1

Among the glucose analogs tested, only those which differed from glucose by a simple change on the number 2 carbon atom have proved effective as inhibitors of anaerobic fermentation. Thus, 2-desoxy-D-glucose, the most potent inhibitor, has had an O-atom removed from this position. D-glucosone, the next best inhibitor, has had two H-atoms removed. D-Glucosamine, the third best inhibitor, has an NH_2-group in place of the OH-group. 2-Chloro-2-desoxy-D-glucose, a relatively weak inhibitor, has a Cl-atom in place of the OH-group. N-Acetyl-D-glucosamine, which has a substituted NH_2-group in place of the OH-group, produced no inhibition, possibly because the larger group makes the analog so different from glucose that it cannot compete with glucose in the fermentation system. Therefore, it appears that not only is the number 2 position important, but that the group in this position determines the degree of inhibitory power of the analog.

iso-Glucosamine, an analog of fructose differing on the number 1 carbon atom, was the only other compound among those tested found to inhibit anaerobic fermentation of glucose. iso-Glucosamine, as would be predicted, inhibited the anaerobic fermentation of fructose more strongly than it inhibited the anaerobic fermentation of glucose. However, it was found that 2-desoxy-D-glucose and D-glucosamine, analogs of glucose, also inhibited the anaerobic fermentation of fructose more strongly than that of glucose. The inhibitory power of 2-desoxy-D-glucose in anaerobic fermentation of fructose is actually much greater than is apparent from the figure of 90 per cent inhibition expressed in Table I for equi-molar amounts of 2-desoxy-D-glucose with fructose. Best comparison may be made from the amounts of 2-desoxy-D-glucose required to produce 50 per cent inhibition with each of the substrates. With glucose a molar ratio of 0.2:1 is required; with fructose a molar ratio of only 0.06:1 is required. Therefore, the effect with fructose is about 3.3 times as great as with glucose. An explanation for this difference is not yet apparent.

2-Desoxy-D-glucose and D-glucosone, the two best inhibitors of anaerobic fermentation, were the only carbohydrate analogs found to inhibit aerobic fermentation. The similarity of effect between these two analogs, however, did not follow in the other phases of oxidative metabolism. 2-Desoxy-D-glucose did not inhibit respiration, while glucosone inhibited respiration greatly. 2-Desoxy-D-glucose, on the other hand, was a very potent inhibitor of growth, while glucosone was a very weak inhibitor. D-Glucosamine and iso-glucosamine, fairly weak inhibitors of anaerobic fermentation, had no effect on aerobic fermentation.

Among the analogs of gluconic acid, ribose and desoxyribose, the only one found effective in inhibiting any phase of carbohydrate metabolism was D-glucononitrile. This analog of gluconic acid inhibited both respiration and growth of yeast. On the other hand, the rate of fer-

mentation under aerobic conditions was increased considerably. Although tests for competitive inhibition have not been made, D-gluconononitrile probably does not inhibit respiration competitively as an analog of gluconic acid, but rather as a respiratory poison because of the nitrile (cyanide) group which it contains. Cyanide has long been known to be a respiratory poison, and the combined effects produced by D-gluconononitrile (inhibition of respiration and stimulation of aerobic fermentation) are like those produced by cyanide on the cancer cell (7).

Several of the carbohydrate analogs stimulated growth of yeast even though sufficient glucose was present to allow maximum growth from the medium. Most noticeable stimulation of growth was produced by iso-glucosamine. Since also D-gluconamide, N-acetyl-D-glucosamine, and even D-glucosamine in low concentrations, stimulated growth, it seems likely that the NH_2 group in these compounds could be used by the yeast as a readily available source of nitrogen for growth.

The list of possible analogs of the known carbohydrate metabolites has by no means been exhausted. Glucose analogs differing from glucose in the 4 and 5 positions and the many possible fructose analogs are particularly interesting as possible antimetabolites for fermentation and glycolysis. Other types of antimetabolites for the carbohydrate metabolism of the nucleic acids should be studied, but prediction of the type most likely to act as an antimetabolite is difficult until there is a better understanding of the enzyme systems involved.

SUMMARY

Structural analogs of glucose, fructose, gluconic acid, ribose and desoxyribose have been tested as possible competitive inhibitors of glucose utilization in anaerobic fermentation, aerobic fermentation, respiration and growth of yeast. It was hoped that an inhibitor of one or more of these processes might be effective in the control of cancer.

Compounds which inhibited anaerobic fermentation were, in the order of effectiveness, 2-desoxy-D-glucose, D-glucosone, D-glucosamine, iso-glucosamine and 2-chloro-2-desoxy-D-glucose.

2-Desoxy-D-glucose and D-glucosone were the only compounds found to inhibit aerobic fermentation.

D-Glucosone and D-gluconononitrile were the only compounds found to inhibit respiration.

Growth was inhibited by 2-desoxy-D-glucose, D-gluconononitrile, D-glucosamine and D-glucosone, in the order of their effectiveness.

(1) F. B. CRAMER AND G. E. WOODWARD, J. FRANKLIN INST., **253**, 354 (1952).
(2) G. E. WOODWARD AND M. T. HUDSON, J. FRANKLIN INST., **255**, 556 (1953).
(3) G. E. WOODWARD AND F. B. CRAMER, J. FRANKLIN INST., **254**, 259 (1952).
(4) J. H. QUASTEL AND A. CANTERO, *Nature*, **171**, 252 (1953).
(5) B. L. HORECKER, P. Z. SMYRNIOTIS AND J. E. SEEGMILLER, *J. Biol. Chem.*, **193**, 383 (1951).
(6) G. E. WOODWARD, J. FRANKLIN INST., **254**, 553 (1952).
(7) O. WARBURG, K. POSENER AND E. NEGELEIN, *Biochem. Z.*, **152**, 309 (1924).

BOOK REVIEWS

IONIC PROCESSES IN SOLUTION, by Ronald W. Gurney. 275 pages, diagrams, tables of critical data, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1953. Price, $6.50.

With this book, Ronald W. Gurney has avoided a very common error. All too often, the scientific treatise is organized in an artificial manner. Possibly this is done so that the reader may be gradually led from the simple to the abtruse or that he may appreciate the subject from the historical or chronological viewpoint. In any case, the student is placed under a severe disadvantage by the illogical approach which must thereby result.

In the present book under review, the author has committed no such sin. On the very first page the general framework of the whole subject matter is already being set into place, and on succeeding pages, the author continues to write in terms of the whole province of his book. He proceeds from the general to the specific, and each chapter actually constitutes an embellishment and commentary on what has gone before.

In the first few chapters of the book, the subjects which are discussed include the potential energies of charged particles in solutions and the structure of such solutions. These considerations are then related to electrolytic conductivity. The next two chapters constitute an interesting discussion of solution thermodynamics in which a statistical approach is used.

Except in the case of some of these earlier chapters, the author makes frequent use of actual empirical data, and based upon these, he has succeeded in presenting a very fine discussion of acid-base reactions and solvent effects from the standpoint of solution structure and thermodynamics. The chapter on galvanic cells was considered to be especially attractive.

Ronald W. Gurney is an excellent teacher. His novel approaches will be appreciated by the student as will be his extremely lucid descriptions. When introducing new subject matter, he carefully reviews what has come before, and in doing so, he anticipates the difficulties which the individual student will meet. The only adverse criticism which may be offered is that the problems given at the ends of the chapters are too few in number and are not sufficiently complex to test adequately the student's grasp of the material.

This book is a theoretical treatment for the experimental electrochemist. The empiricist will gain a new appreciation for much of the data which he has seen before. Such will be the most significant contribution offered by this book.

SIDNEY M. SELIS

FATIGUE OF METALS, by R. Cazaud, translated by A. J. Fenner. 334 pages, diagrams, 16 × 26 cm. New York, Philosophical Library, 1953. Price, $12.50.

The study of fatigue in metals is one in which a wealth of information exists scattered throughout the literature. This information is primarily in the form of experimental results and although it has offered little toward a basic understanding of fatigue failures, it is invaluable in aiding the engineer to design equipment containing metals and alloys subjected to cyclic stresses. The engineer, however, seldom has access to a good technical library, nor does he have the time to conduct a literature survey on such specific subjects as fatigue. As a result he usually depends on texts or handbooks for his primary source of information. Such books obviously should be up-to-date, accurate, and fairly comprehensive.

Dr. Cazaud, eminent in the field of fatigue, has prepared three editions (1937, 1943, 1948) of *La Fatigue des Métaux*. The present book is essentially the 1948 edition translated into English for the first time and is supplemented by more recent work. The author cites very few references after 1949 but, other than this, presents an excellent literature survey in his bibliography of 513 references. This book is the only comprehensive English text on fatigue published in the last decade and as such will undoubtedly be received with considerable interest by all of those interested in this particular subject.

The author has illustrated the book profusely (245 plates) and makes excellent use of the photographs and diagrams to illustrate such things as different types of fatigue failures and fatigue testing devices. For instance, there are over thirty well chosen micrographs of various fatigue failures in Chapter 2. These serve to show the characteristics of fatigue failures very strikingly. Chapter 4 has an equally large number of sketches and photographs that clearly illustrate the principles of fatigue testing equipment.

Chapter 3 summarizes the various theories of the mechanisms of fatigue of metals. This section is accurate, well written and complete. However, this reviewer believes that seventeen pages is much too short for such an important topic as the theory of fatigue.

Thirty-one pages are devoted to the fatigue limit of metals and alloys. Here the author has tabulated data on fatigue which should prove of great value to the designer. Dr. Cazaud has apparently carefully selected data which are complete in regard to chemical composition, heat treatment, and micrographic structure. However, Table III, Chapter 5, tabulates data taken from Dr. Cazaud's own experiments. This table is entitled, "The effect of annealing, over-heating and work hardening on fatigue strength of mild steel." Any effects due to these causes are probably caused by the accompanying changes in grain size. For example this table shows the fatigue limit changing from 20.8 kg. per sq. mm. to 26.6 kg. per sq. mm. with a grain size change of 150 grains per sq. mm. to 900 grains per sq. mm. An examination of other data in this section shows this to be a significant change in fatigue limit and thus one might consider grain size an important variable to be reported. It is somewhat disappointing to find only four out of the several hundred tests tabulated showing what the grain size was in the test piece.

The influence of various factors on fatigue strength and the conditions of application of stress are discussed thoroughly with respect to such factors as frequency of stress cycles, periods of rest after stressing, overloads, shape and size of the specimens, temperature, corrosion, etc. The author has assembled the results of many researchers concerning these factors and presents them in a very orderly, lucid manner. He devotes considerable space to the important subject of improvement of fatigue strength, pointing out how to choose the best metal or alloy and how to properly design components in order to minimize fatigue failures.

It is difficult to place a monetary value on a book, especially one as specialized as this. It is well written, excellently organized, and of significant practical value; however, basing an opinion on prices of comparable texts, this reviewer believes that its retail price is much too high. RAYMOND L. SMITH

MECHANICAL ENGINEERING THERMODYNAMICS, by David A. Mooney. 540 pages, diagrams, charts, 15 × 22 cm. New York, Prentice-Hall, Inc., 1953. Price, $7.00.

Written by a former professor from M.I.T. and presently a practicing mechanical engineer, *Mechanical Engineering Thermodynamics* reflects the author's theoretical and practical background. Purposely an introduction to the broad field of thermodynamics, the book is on the level of a first year course in the subject and its application in mechanical engineering. Recognizing the intangible nature of many of the thermodynamic concepts, Mr. Mooney, of Jackson and Moreland, Engineers, has included a number of illustrative engineering applications and problems. Some students may find certain sections of the book unusually detailed and elementary; but in treating a subject such as thermodynamics it is obviously better to include too much rather than too little.

As stated in the preface, the general order of presentation is basic concepts, principles, data on substances and engineering applications. Following an introduction and review of the fundamental principles of work, temperature, heat and properties of systems, the author discusses the first and second laws of thermodynamics and their applications. He then discusses the properties of pure substances, of gases and gaseous mixtures. Process calculations are next described, followed by various vapor cycles and fluid flow, leading into the function and design of turbines and reciprocating expanders and compressors. The book concludes with accounts of internal combustion power plants and refrigeration. In the back cover, there are temperature-entropy diagrams for carbon dioxide and air, a Mollier steam chart, a psychrometric chart, a chart of the properties of chemically-correct fuel-air mixtures, and a pressure-enthalpy chart for Freon-12. E. W. HAMMER

FORMALDEHYDE, by J. Frederic Walker. Second edition, ACS monograph # 120, 575 pages, diagrams, 16 × 24 cm. New York, Reinhold Publishing Corp., 1953. Price, $12.00.

The second edition of *Formaldehyde* is a considerably enlarged version of the 1944 edition containing the same fine presentation of the material on the subject.

The 21 chapters may roughly be grouped in 6 major categories. The first chapter deals with formaldehyde production. This is followed by 6 chapters on the various forms of formaldehyde, monomer, solutions, and polymers. Nine chapters are devoted to chemical properties and two are on analysis for formaldehyde and of formaldehyde solutions and polymers. A chapter on hexamethylenetetramine is included. The final two chapters deal with the uses of formaldehyde in its various forms.

The enlargement is a general one. The majority of the sections have been expanded to greater detail with only a few short added sections. The only new chapter in the book is that covering reactions of formaldehyde with the nuclei of heterocyclic compounds, including furans, thiophenes, pyrroles, pyridines, and quinolines.

The outstanding quality of this book is its systematic presentation in the arrangement of the chapters and sections and of the material within the sections themselves. No section contains all the material which might be required by one delving deep into a specific topic in formaldehyde chemistry. This would obviously require a work of many volumes. The author is, however, amazingly thorough in his treatment and seems to distribute the space well. References are extensive.

Formaldehyde is a practical book written primarily from an industrial point of view. Numerous parts will, however, be of great help to anyone working with formaldehyde. The enlarged presentation and the fine organization make it a welcome addition to chemical literature. M. H. BORTNER

ROCKS FOR CHEMISTS, by S. James Shand. 145 pages, 32 plates, 15 × 22 cm. New York, Pitman Publishing Corp., 1952. Price, $4.50.

This little book, written by Professor Shand, has three main goals: (*a*) To convince petrologists that the present nomenclature of rocks and minerals is highly inadequate and unsystematic; (*b*) To present the field of petrography and its nomenclature from the standpoint of chemistry; and (*c*) To try to interest the chemists in research in the relatively untapped field of rock and mineral genesis.

The rocks are discussed in the following order: field rocks; rock-forming minerals; active and underground lava; eruptive rocks; plagioclase rocks; dioritic rocks; granitic rocks; syenitic rocks; feldspathoidal rocks-heavy crystal-accumulate-forming rocks; sedimentary rocks; and metamorphic rocks (including their formation by dynamic, thermal, hydrothermal, and complex metamorphism). The author tries to systematically classify rocks and minerals according to the proportions of chemical elements and compounds they contain. Then, by means of phase diagrams, he shows how the many members of a rock family were formed as they cooled from the liquid state. At the end of the book, there is a series of pertinent photographs carefully selected by the author to pictorially emphasize his theories. There is also a list of suggested readings included for readers who wish more detailed information on some subject.

The book is well written; however, in the opinion of the reviewer, the book would stimulate interest much more effectively if the author did not cover so much of the field in such an abbreviated volume. The book would also be more readable if Professor Shand had limited his presentation to only one family of rocks with only general reference to the many others. For chemists, there are so many new rock and mineral names to keep in mind that over-all interest in the field of petrography is lost. However, the book will be very provocative and immensely interesting (and hence is recommended) to chemically trained petrologists. DONALD H. RUSSELL

HIGHER TRANSCENDENTAL FUNCTIONS, Volume I, by Harry Bateman (compiled by the staff of the Bateman Manuscript Project). 302 pages, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1953. Price, $6.50.

"This work is dedicated to the memory of Harry Bateman as a tribute to the imagination which led him to undertake a project of

this magnitude, and the scholarly dedication which inspired him to carry it so far toward completion."

These inspiring words reflect the devotion with which a great scholar pursued an Herculean task: to compile the properties of all transcendental functions that play a rôle in applied mathematics. The publication of this first volume is a credit to many others: Professor A. D. Michal first plowed his way through "a veritable mountain of paper"; the California Institute of Technology and the Office of Naval Research underwrote the project; Professor A. Erdélyi from the University of Edinburgh directed it; Professors W. Magnus, F. Oberhettinger, and F. G. Tricomi from the Universities of Göttingen, Mainz, and Turin, respectively, collaborated with him; six research assistants did the legwork and collected the facts; and the publishers lent their experience to the difficult task of getting thousands of formulas into print.

The first chapter of this volume deals with the properties of the gamma function. It is an elementary chapter in the sense that most readers on this level would recognize or know much of its content. An extensive list of elementary relations includes the beta function, the psi function, the zeta function as well as Bernoulli and Euler Polynomials. The chapter concludes with the polygamma functions and the Mellin-Barnes integrals.

The second chapter covers in two parts the basic theory of the hypergeometric function: theory and formulas. The fundamental relations are followed by a full discussion of the hypergeometric equation in Poole's form. Included is a table of the solutions for the degenerate case in form of the 24 series of Kummer and their analytic extensions. Explicit equations are given under "formulas."

The third chapter treats the Legendre functions. It, too, begins with the basic differential equations. The 36 solutions and their expansions near the three singular points are stated in form of hypergeometric series. More advanced functions found here are the toroidal functions of Laplace, conical and Gegenbauer functions.

The next two chapters concentrate on generalizations of the hypergeometric series. Chapter IV includes the series introduced by Clausen in 1828, the standard type of Saalschütz, Laplace, and Hankel transforms. Chapter V presents further generalizations due to MacRoberts and Meijer as well as hypergeometric functions of several variables.

The last chapter deals with the confluent hypergeometric functions. We find solutions near the origin, integral representations, Laplace transforms, Whittaker functions, and many other relationships.

The tenor of this first of two volumes is descriptive with many short proofs given throughout. Scores of important theorems, over 1600 numbered formulas, and more than 300 references have been compiled. Until now, much of this material had been buried in various places of the existing literature. Nevertheless, the volume does not have nearly the scope envisioned by Bateman, nor does it tap all available sources. Many of the references are of continental origin; they may be almost inaccessible to some American readers. A new edition stands to gain much if pertinent material from the publications of this hemisphere were added. This is especially desirable as the volume is bound to contain mistakes which the conscientious user will want to avoid by comparison with other sources.

The varityping was done efficiently, but sometimes without regard to existing symbolic simplifications. The continued fraction on page 88 and the many binomial coefficients, for example, are written in the "old" form for which space-saving symbols have long been devised. As a whole, however, the volume can become a valuable tool in the hands of applied mathematicians and analysis specialists. Computers have for years had a trusted companion in the well-known Index of Mathematical Tables. A similar service is now rendered on a higher plane by *Higher Transcendental Functions*. CARL HAMMER

CIRCUIT THEORY OF ELECTRON DEVICES, by E. Milton Boone. 483 pages, diagrams, 16 × 24 cm. New York, John Wiley & Sons, Inc., 1953. Price, $8.50.

A number of years ago, when electronics was emerging from the laboratory, Prof. F. E. Terman, at Leland Stanford University, published his widely accepted book "Radio Engineering." Many electrical engineers who graduated before 1940 used this book as a standard text. Now a recent member of the faculty of the Ohio State University, Prof. E. M. Boone, who is also Research Supervisor at the Electron Tube Laboratory of OSU, has finally published his comprehensive book *Cir-*

cuit Theory of Electron Devices. This book speaks well for Prof. Boone and OSU. It is based upon the class notes which the author used for the past ten years in a course given to physics and electrical engineering students at the end of the third and beginning of the fourth year. Constant classroom use over this period has resulted in a book which shows none of the faults commonly encountered in a first edition. The style of writing was easily accepted by this reviewer, the separation of subject matter is logical, and the line diagrams and graphs are sufficient to illustrate the text, and no more. This indicates, at least to this reviewer, that here is an author who has something to say, and who does not clutter up valuable textbook space with useless photographs that can be seen in commercial catalogues.

Prof. Boone's pedagogical thesis is that a student who is just learning circuit theory of electron devices should focus his attention, at first, on this subject only, and he should not be distracted by having to learn about the physics of such devices. This is a most worthwhile approach, for the student is taught electronic circuits from the point of view of network theory, a next logical step after having taken courses in four-terminal network devices. A student who comprehends the text material and the problems given at the end of each chapter, should have no difficulty in designing basic electron tube circuits of a complexity which most physics and engineering school graduates encounter.

Of the twelve chapters in this volume, the first four are devoted to high vacuum tubes, their characteristics and applications as voltage and power amplifiers. Gas-filled tubes as circuit elements are treated in a separate chapter. Single phase rectifiers and power supplies, for low power applications, and polyphase rectifiers for large power applications are treated in two chapters. In some detail, the author analyzes not only efficiency and ripple, but also the response of various commonly used filters, the effect of transformer leakage reactance, and several polyphase rectifier circuits.

Radio frequency circuits are the subject of three chapters, devoted to tuned voltage amplifiers, power amplifiers and modulation and demodulation. This reviewer felt that the chapter devoted to the last mentioned topic was perhaps the weakest in the book. More circuit analysis, such as is presented in the earlier chapters, would do much to strengthen this chapter. Oscillators and transistor circuits are covered in two chapters.

For many of the subjects covered, the author presents worked out illustrative examples of design. These, coupled with the problems and possibly an accompanying laboratory course, would afford good opportunity for the student to learn electron circuit design rapidly.

This reviewer recommends the book to practicing electronic engineers who may have strayed from the path of circuit design and who want to have available a book which deals with the many topics mentioned earlier.

S. CHARP

INDUSTRIAL WASTES—THEIR DISPOSAL AND TREATMENT, edited by Willem Rudolfs. 497 pages, diagrams, 16 × 24 cm. New York, Reinhold Publishing Corp., 1953. Price, $9.50.

This book, a monograph, is a comprehensive presentation of the many aspects of the problem of industrial waste disposal. Widespread pending legislation and court trials had focussed national attention on this problem, making this volume of timely interest. The magnitude and variety of industrial discharges into streams are amazing. It is estimated that half the pollutional load carried by streams and other water courses is caused by industrial wastes. In the highly concentrated areas, the percentage due to industrial discharges is even greater. The problem is one of no mean proportions.

The subject is introduced by a rather brief, but succinct, statement and definition of the problem. Facts and figures are supplied to support the position that the problem is large in scope. The contribution that each of our major industries makes toward swelling the stream pollution problem is treated in some detail by individuals who obviously are familiar with the specific character of these wastes. Descriptions of the processes, the waste products and the efforts made to control and ameliorate the offensive nature of the discharges are given. It is generally agreed that each industry has a specific problem in the treatment of its waste products and from an economic point of view, improvements will be slow.

Some examples of the industries covered are slaughterhouse and meat packing wastes, paper and pulp, coal mining wastes, fermentation, and liquid radioactive wastes. The last one has, of course, introduced new hazards and considerable scientific effort has been made to control it. In all, fourteen major industries are discussed.

A chapter is devoted to the basic principles involved in stream pollution and treatment of these wastes. Physical, chemical, and biochemical effects are discussed in detail. The mechanism of self-purification of the polluted stream by means of bacterial action, chemistry, dilution, and sedimentation is described.

The book is well presented and is highly recommended.

S. N. MUCHNICK

PHYSICAL CONSTANTS OF HYDROCARBONS, Volume V, by Gustav Egloff. 524 pages, 16 × 24 cm. New York, Reinhold Publishing Corp., 1953. Price, $20.00.

In 1919, the American Chemical Society, at a meeting of the Interallied Conference of Pure and Applied Chemistry, agreed to produce a series of Monographs on subjects of chemical interest. The volumes on physical constants of hydrocarbons, of which this is the fifth volume, are part of that now very extensive and significant series.

The data of these books consist principally of boiling points, freezing points, refractive indices, critical temperatures and pressures and complete references of the sources of these data.

This volume describes aliphatic hydrocarbons, as did Volume I which was published in 1939, but brings the data up to date. It also includes some older data which were not present in the first volume and corrects errors noted in the latter. The book is divided into three main headings: alkanes, alkenes, and alkynes (saturated, double bonded and triple bonded structures, respectively). The compounds in each section are listed in ascending order of the number of carbon atoms.

The book represents a most worth-while contribution to workers in the field of hydrocarbon research from one of the most eminent scientists in that field.

ALBERT L. MYERSON

CHYMIA, Vol. 4, edited by Henry M. Leicester. 217 pages, 16 × 24 cm. Philadelphia, University of Pennsylvania Press, 1953. Price, $4.50.

The fourth volume of *Chymia* gives another collection in this series of studies in the history of chemistry, not chemistry as a science so much as various personages involved in chemistry in some way. Of the ten articles a few will be of interest to most everyone. It is doubtful if many readers will find more than half to be of any considerable interest.

Of these articles probably the most interesting is that entitled, "Benjamin Rush, Chemist" written by Wyndham Miles. It tells mainly of Rush's teaching at the College of Philadelphia where he was the earliest chemistry teacher of distinction in America. His general ideas on education are given and his course is outlined and to some extent described. Other important features of his life, such as his own education and his important work during the Revolutionary War, are given some attention. There are a large number of quotations from Rush's correspondence and other early sources.

"Auguste Laurent, Founder of Organic Chemistry" is a lengthy description of an argument between Laurent and Dumas concerning original ideas on halogen derivatives formed by substitution and addition. Some biographical material is given with emphasis on certain aspects of his work.

"Contributions of Maxwell Simpson to Aliphatic Chemical Synthesis" is a well-organized description of Simpson's professional life with some concise detail of his original contributions.

An article on "Madame Lavoisier" deals mostly with her unhappy marriage to Count Rumford although some account is given to her scientific interest in M. Lavoisier's work.

"Zukunftsaufgaben der Geshichte d Alchemie" is an interesting article worth reading but that entitled "On the Origin of Alchemy" is of less interest.

Other articles, found to lack much interest, are "A Projected but Unpublished Edition of the Life and Works of Robert Boyle," "Zur Vorgeschicte des Messner Porzellans," "Charles Caldwell and the Controversy in America over Leibig's Animal Chemistry," and "The Scientific Background of Chemistry Teachers in Representative Pharmacy Schools of the U. S. during the 19th Century."

Chymia can thus be recommended for some interesting reading in a few odd hours, particularly the articles on Rush and Simpson.

M. H. BORTNER

ELEMENTS OF HEAT TREATMENT, by the late George M. Enos and William E. Fontaine. 286 pages, diagrams, 15 × 24 cm. New York, John Wiley & Sons, Inc., 1953. Price, $5.00.

The engineer is faced with a perplexing problem when he finds it necessary to heat treat an alloy to obtain certain characteristics. In recent years this problem has become more complex due to the ever increasing number of new alloys evolving from our research laboratories. Although this book deals with the subject of heat treatment, it devotes only twelve pages to the heat treatment of nonferrous alloys and consequently is of limited use to those not particularly interested in ferrous materials. However, the rudiments of ferrous heat treatment are presented in an adequate, simple manner, and involve useful general principles. The authors discuss such processes as annealing, normalizing, tempering, nitriding, carbonizing, etc. They present enough of the background material concerning each process so that the reader will not have to heat treat by "cook book" methods. The chapter on hardenability is especially well written. It includes a detailed discussion on the important Jominy Test and time-temperature transformation curves (S Curves).

It would be unusual for a reader to be in complete agreement with the authors in their choice of material. This reviewer believes that the discussion concerning stress-strain curves should include an explanation of natural strain. This representation of strain is becoming quite popular when tensile data are plotted as stress *vs.* strain. The engineer accustomed only to ordinary strain as described by a change in length could easily be quite confused if confronted with strain defined as:

$$\epsilon = \int_{L_0}^{L_l} \frac{dL}{L} \text{ or } \ln \frac{L}{L_0}$$

where ϵ = natural strain, L_0 = initial length, L_l = instantaneous length.

Further clarification is needed concerning the authors' definition of ductility as being the ability of a metal to permit plastic elongation. The engineer usually measures change in elongation by the use of gage marks or extensometer readings. This is sufficient as long as the tensile specimen does not neck locally; however, it yields misleading results for those specimens in which the neck does not fall entirely within the gage marks or extensometer grips.

In their brief discussion of mechanical properties *vs.* temperature the authors state that properties such as plasticity, elongation and reduction of area vary directly with temperature. This does not hold true for all metals over the whole temperature range (0°K. to the melting point of the metal). Certain face centered cubic metals show no significant change in these properties below room temperature, and there are cases in which they actually increase with decreases in temperature below room temperature, for example, annealed cupro-nickel. Both copper and nickel have been reported to decrease or increase slightly in ductility below about 200C. depending on the investigator. In any event it is not correct to state that metals undergo a decrease in ductility with decreases in temperature unless it is stated what the conditions are as to temperature ranges and metals involved.

This book is a worthwhile addition to the library of those who have had relatively little training in metallurgy and who are interested in determining a necessary ferrous heat treatment and understanding the principles behind it. It contains numerous cartoon-type illustrations, a table of contents, and an index. It does not list any references due to the general nature of the subject material.

R. L. SMITH

FABRICATED MATERIALS AND PARTS, by T. C. DuMond. 332 pages, illustrations, 15 × 22 cm. New York, Reinhold Publishing Corp., 1953. Price, $6.50.

The precise text of this publication is a rarity and in view of its moderate size, it has brought together a quantity of satisfying material which heretofore existed only in scattered places such as trade and professional magazines and technical papers. Even though all details that may enter into the design and a choice of manufacturing method for a particular part are not present in this volume,

V. 19

much important information is available for a selection of the most suitable combination upon which to concentrate an effort for design and production. It is the type of book that has been often desired by many engineers, production and management executives.

Throughout its pages, the emphasis is on comparison of cost against the various factors involved in selecting the most fitting method for profit-making manufacturing of small industrial parts. Containing one hundred and seventeen illustrations along with twenty tables of up-to-date data, it is a most informative and valuable reference volume for anyone concerned with design, production and profitable use of such parts.

Mr. Dumond's writing style is direct and concise, and completely free of any confusing "double talk." All considerations are fully covered and with the large type, adequately spaced, the reading is easy and rapid with no time wasted in digesting the information. Especially informative are all of the data tables and the appended fold-in chart inside the back cover. This chart may be described as a comparative summary of manufacturing processes and the many elements influencing the use or choice of the processes.

The twenty major procedures described in this volume include all known developments. The newer methods, too young for complete analysis, are presented to the extent of known facts. Quantities of books have been published on specific design and manufacturing processes, but here we now have one covering them all, in an easy-to-get-at presentation which makes it a welcome addition to any personal or technical library. S. T. FRY

NEW SCREEN TECHNIQUES, edited by Martin Quigley, Jr. 208 pages, illustrations, 16 × 23 cm. New York, Quigley Publishing Co., Inc., 1953. Price, $4.50.

In the latter part of 1952 the movie industry unfolded to the public a new and yet old technique for the filming and presentation of motion pictures. Since then there have been renewed interest and a competitive race to develop commercially three powerful methods for this mode of entertainment. These are three dimensional (3-D) or stereoscopic motion pictures, wide screen pictures (W-S) which have their width about 1.6 and 3 times their height, and stereophonic sound (S-S) whose distribution and location are both controlled. This book is an up-to-date account of these three new and powerful entertainment types and art forms. It consists of 28 short chapters authored by individuals who are leaders in the production and exhibition of motion pictures, including such experts as Herbert T. Kalmus, Jack L. Warner, Fred Weller, Lowell Thomas, Spyros Skouras, Darryl Zanuck and others.

The successful introduction and a continuous acceptance of 3-D, W-S and S-S require a broad understanding of the interrelations of showmanship, technical skill, story selection, direction, customer selling and creative talent. These are but a few of the topics considered in this volume. In particular, separate articles discuss principles of 3-D photography, production and projection as exemplified by natural vision ("House of Wax"), principles of W-S techniques as exemplified by cinerama ("This Is Cinerama") and cinemascope ("The Robe"), and the techniques and contributions of spread-out sound when used with these visual techniques.

The flood of half-truths, wild rumors and undependable and sweeping statements which naturally seem to follow upon pioneering techniques, especially in the motion picture industry, are dispelled in this book. Those who wish a factual and impartial presentation of this new art form would do well to read this book. S. CHARP

INTRODUCTION TO ELECTRON MICROSCOPY, by Cecil E. Hall. 451 pages, illustrations, diagrams, 16 × 24 cm. New York, McGraw-Hill Book Co., Inc., 1953. Price, $9.00.

This excellent introductory text on electron microscopy evolved from a course of lecture and laboratory exercises offered to graduate and advanced undergraduate students at M.I.T., and is published as part of the International Series in Pure and Applied Physics. Sections of its contents should appeal to readers of varied interests from the laboratory technician with little formal background to the project engineer seeking a thorough understanding of all phases of electron microscopy.

The first two chapters serve as an introduction for the less advanced student and as a review for the more advanced student of the elements of physical theory concerned with

the mechanics of the electron and geometrical optics. There follows a discussion of electrostatic and magnetic lenses, including aberration, diffraction, etc. The reader is now prepared for a description of the electron microscope and the image characteristics thereof, together with a short section on the various commercial microscopes. The last third of the book describes methods and examples (of specimen preparation, etc.) in applied microscopy.

Five or so problems are listed at the end of each chapter, answers to some of which are listed in the back of the book. The descriptions of laboratory techniques are taken from the lab procedures carried out by the students taking the course. Each section is amply illustrated with pictures and diagrams. Hence we find that the author carries out very well his expressed intention to provide the reader with a guide to developing creative thinking in the field.

Since the author's interests admittedly lie mostly in the field of biophysics and since the book has been written for students from the Junior level up, the section on electron diffraction is short, though concise.

ROBERT S. SMITH

BOOK NOTES

TEXTBOOK OF GENETICS, by William Hovanitz. 419 pages, illustrations, plates, 16 × 24 cm. Houston, Elsevier Press, 1953. Price, $5.95.

Incorporating the latest research findings, this new general text on genetics will be welcomed by students and research workers in the field. Extremely comprehensive in its coverage of plant and animal life, this scholarly work stresses the Genotype as the principal component of an organism rather than the Phenotype. An outstanding chapter is the one on probability, which is clear even to those with no special training in mathematics. Chromosome behavior and structure are carefully considered, along with linkage, probaity in gene segregation and assortment, mitosis and meiosis, plant and animal improvement and population genetics. Many tables of data and 266 illustrations round out this excellent work, which is highly recommended.

WAYS OF MAMMALS, by Clifford B. Moore. 273 pages, 14 × 21 cm. New York, The Ronald Press Company, 1953. Price, $3.50.

Written by an authority on mammals, this little book is a fascinating story about animals and their behavior. The reader is treated not only to the facts of animal behavior, but also to an unusually vivid and lively account of the many superstititions about mammals that have been handed down to us for generations. The chapters are further enlivened by quotations from books and newspapers. This reviewer was intrigued by the refutation of the old adage "You can't teach an old dog new tricks," and by the account of the waltzing mice. If you like animals, this book will give you many hours of pleasure.

PROBLEMS IN ORGANIC CHEMISTRY, by Edward G. Rietz and C. G. Pollard. 332 pages, 14 × 22 cm. New York, Prentice-Hall, Inc., 1953. Price, $3.95.

Prepared as a supplemental text for a standard organic chemistry course, this useful volume should be helpful to the students who are faced with "homework" when the instructor is not available for questioning. Each of the 29 chapters is devoted to one particular class of functional compound (for example, alkanes, esters, amides, diazo compounds), and each chapter briefly but clearly covers nomenclature, preparations, physical properties and reactions of that class. Problems are found at the end of each of the chapters and a very complete answer section, covering nearly 100 pages, is a most useful check on the student's grasp of the subject.

ELECTRICAL ENGINEERING, by Fred H. Pumphrey. Second edition, 404 pages, illustrations, 16 × 24 cm. New York, Prentice-Hall, Inc., 1953. Price, $6.00.

In this second edition of *Electrical Engineering* (first, 1946), the author has used entire chapters and sections from his 1951 work "Fundamentals of Electrical Engineering," perhaps with the intention of combining the best from the two separate works into a single elementary text for the general engineer. In its present form, more than half the text is devoted to a review of basic electrical engineering theory, while the remainder covers typical applications of that theory.

CURRENT TOPICS

Protection for Tiny Bearings.—Dirt, lint and contaminated atmospheres will no longer be a limiting factor in the application of miniature ball bearings according to Miniature Precision Bearings, Inc., Keene, N. H. The company has announced a new series of single and double-shielded miniature fractional inch size precision ball bearings of both full race and retainer type construction, not previously available. These new bearings, down to 0.1562 (5/32 in.) outside diameter are now in production in nine sizes.

The single shield design bearings are dimensionally interchangeable with the well-known MPB standard unshielded types in most sizes. The double-shielded series bearings are of slightly increased width over catalog dimensions for standard miniature ball bearings.

Shields have well recognized advantages in larger ball bearings, but have previously been unavailable in miniature inch bearings. MPB has ingeniously solved the obvious difficulties of efficient shielding in this size range and is producing bearings with full protection against foreign matter without increase in torque over unshielded bearings.

The shields are recessed to avoid interference with shaft shoulders or housings, thus allowing full freedom in tolerances for users. The shields are removable for bearing re-lubrication or inspection.

Resembling tiny saucers with center holes, the shields on the outer circumference fit into a recess in the outer race of the bearing and are positively positioned by a retaining snap ring. The inner circumference of the shield fits close to the shoulder of a relieved land on the inner race, permitting a clearance of less than 0.002 in. This precision fitting method used by MPB provides a barrier both to the intrusion of foreign matter and the extrusion of lubricant without sacrifice of anti-friction qualities of the bearing.

Miniature Precision Bearings, Inc. manufactures ball bearings from 1/10 to 5/16 in. over-all diameter in more than 150 standard types and sizes. The new shielded bearings are being produced in both chrome bearing steel and stainless steel; all shields are of stainless steel. The bearings are used in a variety of precision mechanisms such as miniature blowers, small electric motors, textile rollers and wherever lint, dust or other foreign matter is present.

Lighting Engineers' Show.—Nearly 100 new lighting products and techniques, representative of the many technical advances made in light sources and lighting equipment during the past year, were demonstrated to 2200 persons attending the progress report session of the Illuminating Engineering Society's annual conference in New York.

Many innovations in home lighting, including a new "bubble" lamp utilizing a plastic cocoon technique, were featured in the report. A 2,000,000-candlepower tank light, radio-active personnel markers and reflectorized phosphorescent tape were some of the new developments in the military field.

The latest electronic theater lighting control system was used to light the stage and ballroom for the pro-

gram, and other remote control theatrical lighting units also were demonstrated.

Several improved types of street lighting lamps were exhibited, and others were shown on color slides of actual installations. A full size demonstration of fluorescent street lighting was also shown.

New photographic lamps, including sub-midget photoflash lamps and projection lamps, were other new products whose technical characteristics were disclosed to the hundreds of lighting engineers present for the report.

Developments in foreign lighting techniques and equipment were highlighted by a color-slide presentation of the novel interior and exterior lighting employed for the recent coronation in London.

Among the other featured presentations were glass and plastic materials for obtaining maximum use of daylight, a 1550-watt infrared heat lamp used as a top burner in an electric kitchen range, and recent lighting applications in the industrial, commercial and school-lighting fields.

The progress report was under the supervision of Ted Sargent, lighting authority of Sylvania Electric Products, Inc., who is chairman of the progress report committee of the Illuminating Engineering Society.

Project Tinkertoy.—The government has announced a project which should be of paramount interest to everyone connected in any way with the electronics industry. The installation opened for study is known as Project Tinkertoy, so named because it reduces the problem of manufacturing complex electronics parts (for example, resistors and capacitors for radio and radar) to a process requiring little more delicate handwork than the assembly of a Tinkertoy windmill.

Project Tinkertoy did not come about by chance, but was developed to meet a definite need. The Navy's Bureau of Aeronautics and the National Bureau of Standards have been working diligently on it since June of 1950. The urgency of the project stemmed from the fact that airplanes could be produced faster than the electronics equipment to go with them. In recent years there have been dozens of instances where military aircraft have been sent out to join operating units with important electronic gear missing or inoperative because of the lag in electronic output. Obviously, this could become a tremendous hazard in the event of all-out attack by a hostile power.

Project Tinkertoy will help solve the problem, since the assembly system it utilizes will reduce the lead time required to produce new electronics equipment by 75 per cent. In addition, it will reduce costs, simplify maintenance, save space and cut down on usage of several critical materials.

Conceived and developed by the National Bureau of Standards, the project has culminated in development of a machine system for manufacturing modular-type (or building-block) electron tube stages, including the related resistors and capacitors, from basic raw materials. The machine-made modules are mechanically assembled into printed-circuit base plate combinations, and these in turn are combined with one another and with other large-dimension basic components to form functional sub-assemblies.

The result is elimination of a vast amount of handwork ordinarily required to manufacture and maintain electronic gear. Previously there had been no substitute for the worker with the thin wires and soldering iron. Project Tinkertoy introduces a number of radically new machines to take the tedium and potential human error out of the job.

A pilot plant utilizing these machines has been constructed in Arlington, Va., under the technical direction of the National Bureau of Standards, and will show commercial manufacturers how best to adapt the process to their own uses. It covers 15,000 square feet of floor space and utilizes only 35 workers. Observers will be given an opportunity to see basic raw materials, such as talc, kaolin, barium carbonate, silver paint and solder, fed in at various stations along a 300-ft. assembly line, mechanically combined and eventually ejected at the finishing point as completed electronic modules.

These modules are currently being used to make sonobuoys (used in aerial anti-submarine warfare) but the system is so flexible that in a few minutes it can be switched to production of simple radio sub-assemblies. The present plant is designed to turn out 1000 modules an hour and 6000 to 7000 sonobuoy electronic installations a month, with 100 per cent automatic inspection for both physical and electronic characteristics.

Project Tinkertoy's biggest accomplishment is that it makes it possible for the electronics industry to convert swiftly from civilian to military production (and back again) on short notice. Costly delays caused by personnel recruiting and training and procurement of new parts and mechanisms are eliminated, and increased production need not be accompanied by proportionate increases in the working force. Performance of equipment produced by the new system appears to equal that obtainable from conventional assemblies.

Though the original plant cost several million dollars, since each new machine involved extensive research and experimentation, it is probable that future installations with similar machines can be produced for much less.

Photosynthesis in Plant Life.—A series of experiments with radioactive carbon has shown that the photosynthetic "factory" which produces sugars and other chemicals inside a green plant cell occupies a fixed location while there can be no more than one "warehouse" where such chemicals are stored. This was reported at the physiological section of the annual meeting of the Botanical Society of America by Dr. Paul R. Gorham of the National Research Council of Canada, Ottawa.

Single, giant-sized cells of a freshwater plant, *Nitella*, were given different amounts of time to produce chemicals from the raw materials of photosynthesis, water and carbon dioxide. Production was then halted suddenly by freezing the cells and drying them in a special way.

By using radioactive carbon dioxide instead of the ordinary carbon dioxide of the air, Gorham was able to locate the positions of the factory and warehouse by simply finding out which parts of the cell had become radioactive up to the time that production was stopped.

To do this, he stuck thin sections of the dried cells on photographic film and allowed the radioactive regions to blacken it. The blackened regions, seen under the microscope, enabled him to locate the factory and warehouse sites.

The factory region, he found, is just inside the cell wall, in a jelly-like layer where the "power plants" for photosynthesis are located. These power plants are the tiny chlorophyll-bearing bodies which capture the light energy needed to run the process.

The chief warehouse region, Gorham found, was located in the same general area as the factory, and not, as expected, in the circulating stream of syrupy fluid that is continually flowing past the power plants.

When this flow is stopped for a few minutes, by shocking the plant, some of the storage products of the factory are transferred to a new warehouse, the stream itself. Why this does not happen when the stream is moving is not yet known.

Locating the photosynthetic factories and warehouses contributes to a better understanding of how plants manufacture the food on which man and animal alike depend.

Millionth-of-a-Second Pictures.—What happens during each millionth of a second from the instant a photographer presses his camera's shutter button and the moment his photoflash lamp has illuminated the scene he captures on film? Developments in high speed photography have recently made possible motion picture film examinations of the milli-second happenings inside of the photoflash lamp, I. S. Goodman, lamp engineer for the Westinghouse Lamp Division, said in a report presented to the National Technical Conference of the Illuminating Engineering Society in New York.

Mr. Goodman demonstrated the efficiency of new high-speed cameras which make it possible to take pictures at 10,000 frames a second and project them for examination at the normal speed of 10 to 16 frames a second. Applying his laboratory investigation to some of the complexities of electric light manufacturing, he said it now is possible to watch the complete, split-second start of a mercury lamp, used for street and industrial lighting, and other "instantaneous', phenomena which, until recently, were in the realm of theory or speculation.

New Constant-Current Street Lighting Transformer.—A new light-weight constant-current street lighting transformer, designed to permit direct pole mounting of models up to and including the 20-KW size, has been announced by the General Electric Company's Lighting and Rectifier Department.

The new transformer, designated G–E Type RO2, ranges from 20 to 33 per cent lighter than former units of comparable ratings, according to G–E engineers. It permits easy adjustment of weights, without removing the transformer cover, through an outside handhole located above the transformer's oil level. Covers can be removed easily by loosening one bolt holding the clamp band instead of the four to five bolts previously required.

The only accessories necessary for direct pole mounting of the new transformer are pole bolts, nuts and washers. This feature, together with the light weight, reduces considerably the time required for an installation.

Cable connections can be made quickly without tools by inserting the cable from either direction into the bushing and tightening the insulated hand wheel.

A new coil design, resulting in faster response to load changes, completely eliminates the counter balance and introduces parallel straight line motion. This design change also reduces the friction points to one main roller-bearing assembly and one guide assembly which makes the transformer more responsive to slight changes in load. An Alnico magnet compensating assures a flat regulation curve.

The design of the new G–E transformer permits use of any type of lamp load—filament, sodium vapor, mercury vapor, or fluorescent. Telephone interference resulting from harmonic distortion caused by discharge lamps is eliminated as a result of the choke

action of the inherently high reactance of the moving coil transformer.

High quality paper and cotton insulation used on the conductors, which are protected by kraft paper between layers and impregnated with waterproof compound, contributes to long transformer life. Baked on Glyptal* paint provides an oil-proof finish that is tough and resistant to abrasion. The tank's finish is flexible and does not creep during temperature changes, inasmuch as the paint is extremely resistant to weathering. Oil life is prolonged by means of the sealed tank construction which effectively prevents contaminations from entering the unit.

A streamlined appearance is the result of a slightly increased over-all height with a corresponding decrease in diameter to provide better proportions, G–E engineers said.

The new Type RO2 constant-current transformer is presently available in standard ratings.

X-Ray Therapy for Skin Infections.—Experiments on the effect of X-ray therapy on experimental skin infections has shown that irradiation has little beneficial effect on such infections and often may do more harm than good, a University of Wisconsin medical scientist reports. The report of the experimental work was presented recently by Dr. Murray Angevine, chairman of the UW Medical School's department of pathology, to physicians attending a symposium on inflammation held as part of the International Physiological Congress in Montreal. The experimental infections may be comparable to skin infections in humans caused by hemolytic streptococcus and staphylococcus for which irradiation is sometimes prescribed.

In animals given X-ray treatment after the organisms had been injected under the skin, the X-ray hastened the stage at which tissue destruction was apparent, Dr. Angevine found. Of 50 animals with skin infection given X-ray treatment, 32 had a more severe infection than would have been expected had the X-ray treatment not been given.

The Wisconsin scientist also found that a larger number of the disease organisms were present in the skin of the X-rayed animals than the non-X-rayed, and that the number of organisms present in the lymph nodes near the site of the X-ray treatment was greater than in the nodes near untreated sites on the bodies of the animals.

Dr. Angevine concludes that "the effect of X-ray treatment upon experimental skin infections was to increase the size of the lesions, to produce more necrosis, and enhance the invasiveness of the micro-organisms."

In reporting another finding, Dr. Angevine says it has been learned that the fibrin of the blood apparently plays a part in localizing infection. When a chemical known as dicumarol, which keeps blood from clotting, is administered to a laboratory animal, a local skin infection quickly spreads over the body surface and results in acute septicemia. It was also found that the skin of these animals administered dicumarol had smaller amounts of fibrin than animals not given dicumarol.

"These experiments seem to indicate clearly that fibrin probably does play a role in localizing infection, but as yet we do not know the physiological mechanism by which fibrin accomplishes this," Dr. Angevine says.

* Registered Trade-Mark General Electric Company.

Automatic Residential Heating and Air Conditioning Systems.—A new, completely automatic heating and air conditioning system that requires no combustion and uses no water is now available from the Westinghouse Electric Corporation. Called the Type HP Heat Pump, the new system keeps the home at the proper temperature for maximum comfort throughout the year. It provides heat in the winter, cooling and dehumidification in the summer, and ventilation, circulation, and continuous cleaning of the air.

The new all-electric unit depends solely on air for its exchange medium. In summer it draws heat from inside air and discharges it to the outside. In winter the heat pump reverses itself—draws heat from outside air, and delivers it to the inside. Completely automatic operation of the reversing cycle is made possible by the development of a simplified transfer valve for refrigerant flow control. This device when connected with a wall thermostat automatically switches the unit from heating to cooling, and vice versa.

Through the use of a specially designed metering tube the need for expansion valves and check valves is eliminated—both sources of trouble in early heat pump models.

The heat pump is entirely self-contained and installation is reduced to the connecting of electric power lines, a condensate drain, and supply and return air ducts. The unit occupies a minimum of floor space, the three horsepower size requiring only ten square feet.

For best results, the heat pump is most adaptable to areas of the country where the low temperature range is not extreme or of long duration.

Air ducts can return either under the floor at the bottom of the unit or through the side. The outside air connection is normally stubbed directly through an outside wall. The heat pump is designed for installation with its back next to a wall and in one corner if necessary. Access is required only to the front for service adjustments to all components.

It is available in two sizes, a three horsepower model having a nominal heating and cooling capacity of over 30,000 Btu/hr., and a five horsepower model having a nominal capacity of over 50,000 Btu/hr.

"Air-Borne" Concrete, Mixed Underground.—A "push button" system of blowing concrete by compressed air through pipe from underground mixing stations into construction forms has been installed by The International Nickel Company of Canada, Limited, at its Creighton Mine. This system of utilizing "air-borne" concrete is greatly expediting the company's program of mining by induced caving.

To stabilize areas of the mine worked and abandoned 40 or more years ago, and utilize old openings in which the timber supports have rotted and collapsed, extensive concreting is necessary. Very slowly and often only with the greatest difficulty could concrete be delivered to these locations until the "push button" system of blowing it there by compressed air was installed.

Several thousand bags of cement a month are now being used underground at Creighton to build slusher stations and drifts, boxhole brows, switchrooms and other installations required to meet the caving project's quota of 12,000 tons of ore per day. Concrete mixing stations are located on the 6th and 20th levels. Gravel for the concrete is received at the mixing stations by gravity from surface through a raise formerly used for

bringing rock fill to the various levels of the mine. Control chutes have been installed in the raise for handling the gravel at each station. Cement is brought from surface by the mine's regular transportation system.

Located in large rooms which provide ample space for cement storage, the mixers can produce a 16-cu. ft. batch of concrete every three minutes. It is poured into the placer, a cylinder 2½ ft. in diameter by 10 ft. long, into which compressed air is then introduced from the mine's main air line.

From the placer the "air-borne" concrete is blown through a line of 6-in. steel pipe which carries it along levels, up or down manways, and through twists and turns of the mine's workings until finally, perhaps a quarter of a mile or more from the mixing station, it drops right into the forms at the construction site.

At 90-deg. turns in the line T-bends are used; an air cushion which forms in the dead end of the T greatly reduces abrasion from the concrete. On long curves sections of 8-in. pipe are inserted, with Ni-Hard liners; standard steel elbows last as little as two hours under the impact of the concrete at these turns but the Ni-Hard liners, made of a very tough nickel alloy, were unchanged after six months of operation.

The men operating the concrete placers take pride in the astonishing performances racked up to date. Best "up" delivery so far was a total of 1,315 feet from the 20 level placer, consisting of 875 ft. on 20 level, up 210 ft. on a 47-deg. incline, 100 ft. on the level, up 50 ft. at 90 deg., and finally 80 ft. on the level. The 6 level station takes credit for the longest "down" delivery to date, a total of 1670 ft. from the placer into the forms for a new slusher station on 14 level.

Miniature Motor for Use in Bombers.—A miniature direct-current motor, probably the smallest ever built by General Electric, is currently being produced by the company's Specialty Motor Sub-Department for use in defense systems of the most advanced operational bombers.

About the size of an ordinary ink bottle—1⅝ in. in diameter and 2¾ in. long—the tiny motor weighs approximately eight ounces. Rated at two-thousandths (0.002) horsepower at a speed of 6500 rpm., it is so sensitive that it is controlled by the output of two small vacuum tubes.

Of the split-shunt, reversible-rotation type, drawing maximum armature currents of 0.8 ampere from a 28-volt line, the "Tom Thumb drive" is required to withstand a high potential of 1500-volts above the ground. It is capable of responding to field currents of 0.00075 amps.

The small motor is designed to be at home at sea-level atmospheres or at altitudes as much as 50,000 ft., and in temperatures as low as −65 F. It is unaffected by dry, hot, or humid environmental conditions, according to G–E engineers.

Planes and Oil Aid Weed Control.—When Orville and Wilbur Wright ushered in the age of powered flight 50 years ago, they probably didn't dream of the multitudes of uses to which Americans would put airplanes. An important use is the control of weeds by means of airborne sprays. Not only farms, ranches and home gardens benefit from the spraying, but airports, oil installations and railroad rights-of-way are kept free of mesquite, poison ivy, poison oak, barberry and brambles. Oil, a partner in these operations, serves both as fuel for the planes and in the form of petro-chemicals in the sprays.

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